AD F300 332

AD-A135 784

MEMORANDUM REPORT ARBRL-MR-03308

WIND TUNNEL TESTS ON A NONAXISYMMETRIC PROJECTILE SHAPE AT MACH NUMBERS 2.5 TO 6.0

Lyle D. Kayser

September 1983

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MEMORANDUM REPORT ARBRL-MR-03308	2. GOVT ACCESSION NO. AD-A135 784	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WIND TUNNEL TESTS ON A NONAXISYMMETRIC PROJECTILE SHAPE AT MACH NUMBERS 2.5 TO 6.0		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Lyle D. Kayser		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Ballistic Research Laboratory ATTN: DRDAR-BLL Aberdeen Proving Ground, Maryland 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS RDT&E 1L162618AH80
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command US Army Ballistic Research Laboratory (DRDAR-BLA-S) Aberdeen Proving Ground, MD 21005		12. REPORT DATE September 1983 13. NUMBER OF PAGES 49
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Projectiles
Supersonic
Nonaxisymmetric
Nonconical Boattails

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Wind tunnel tests on spinning nonaxisymmetric projectile configurations at Mach numbers of 2.5 to 6.0 are reported. The projectile shapes are ogive-cylinder bodies which have been modified by machining three forward facing surfaces and three rearward facing surfaces on the projectile. The machined surfaces are twisted at a rate corresponding to a typical rifling twist. The forward facing surfaces produce a helical or corkscrew type effect and the rearward surfaces form a nonconical boattail and a triangular base. The

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

objective of the test program was to study shapes which have improved stability characteristics which require less gyroscopic stabilization. A more slender, longer L/d projectile can then be flown which has lower drag and shorter time of flight to a moving target.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

I. INTRODUCTION

Some studies on the aerodynamic properties of nonaxisymmetric projectiles have been carried out in the Ballistic Research Laboratory in recent years. Figure 1 shows photographs of three such shapes which are designated as semicorkscrew, nonconical boattail, and corkscrew shapes. Platou[1-4] has considered nonaxisymmetric boattail shapes and has demonstrated that the projectile stability can be improved while still retaining the advantage of drag reduction through nonconical boattailing. For spinning projectiles, the boattail surfaces must be twisted at the same rate as the rifling twist. A resulting benefit of this twist is a reduction of the Magnus moment. Platou considered several nonconical configurations such as triangular, square, and cruciform. He concluded that the three-surface triangular boattail has the best aerodynamic properties. Later Platou[5] considered forward facing, and twisted, surfaces which gave the projectile a sharp nose tip and triangular cross sections near the nose; this shape was designated the corkscrew projectile. The general findings for the corkscrew shape were: (1) a low drag coefficient, (2) small Magnus moments, (3) smaller pitching moments than axisymmetric configurations of the same L/d. Platou[6] reports results of a study where he considered aerodynamic and physical properties of projectiles which could decrease projectile time of flight and therefore be more effective against maneuvering targets. Various geometries considered in Reference 6 were: conventional, nonconical boattail, corkscrew, and semicorkscrew shapes. The semicorkscrew shape shown in Figures 1 and 2 was considered by Platou to be a more practical shape than the sharp nose corkscrew shape. The semicorkscrew shape is primarily the subject of this report.

---

1. *Platou, A.S., "An Improved Projectile Boattail," ARBRL-MR-2395, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, July 1974 (AD 785520).*

2. *Platou, A.S., and Nielson, G.I.T., "An Improved Projectile Boattail. Part II.," BRL R 1866, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, March 1976 (AD A024073).*

3. *Platou, A.S., "An Improved Projectile Boattail. Part III.," ARBRL-MR-2644, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, July 1976 (AD B012781L).*

4. *Platou, A.S., "An Improved Projectile Boattail. Part IV.," ARBRL-MR-02826, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, April 1978 (AD B027520L).*

5. *Platou, A.S., "Aeroballistics of Corkscrew Projectiles," ARBRL-MR-02825, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, April 1978 (AD A054735).*

6. *Platou, A.S., "Decreasing the Flight Time of Bullets by Improving Its Aerodynamic Characteristics," ARBRL-MR-03103, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, May 1981 (AD B058203L).*

Other nonconical boattail results are reported in References 7 to 9. In Reference 7, computations on axisymmetric shapes were compared to experimental results on nonaxisymmetric shapes. The basic finding of Reference 7, for supersonic speeds of M = 1.75 to 4.0, was that the triangular nonconical boattail increased the static stability and in some cases, the stability is greater than that of a straight cylindrical (0°) boattail. In Reference 8, Danberg and Tschirschnitz obtained pressure measurements on axisymmetric and nonconical boattails at transonic speeds. Intergration of pressures over the boattails showed that the nonconical boattail reduced total projectile drag by approximately 15% and increased the static stability with respect to the conical (axisymmetric) boattail configuration. Wind tunnel results for a projectile with a one-caliber triangular boattail are presented in Reference 9 for M = 0.91 and 3.0. The results show improved stability at both Mach numbers. Also presented in Reference 9 are computational results for the nonconical boattail at M = 3.0; agreement between computation and experiment is generally good. The computational method used was the parabolized Navier-Stokes solver described in Reference 10.

The above references document desirable aerodynamic characteristics of nonaxisymmetric shapes, but whether or not such shapes can be successfully flown has not been fully determined. Sabot design for the complex semicorkscrew shape is difficult and the launch dynamics are complex. For example, free-flight launchings of the semicorkscrew shape have shown large initial yaw which has overshadowed other desirable aerodynamic characteristics. Currently there is not a major effort in the study of nonaxisymmetric shapes here at the Ballistic Research Laboratory. However, there are currently computational projects involving nonaxisymmetric shapes including finned bodies. The experimental results of the semicorkscrew projectile presented in this report can be of value in providing guidance and verification of the computational effort.

---

7. *Kayser, L.D., and Sturek, W.B., "Aerodynamic Performance of Projectiles with Axisymmetric and Non-Axisymmetric Boattails," ARBRL-MR-03022, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, May 1980 (AD A086091).*

8. *Danberg, J.E., and Tschirschnitz, R.H., "Transonic Pressure Distribution and Boundary Layer Characteristics of a Projectile with an Asymmetric Afterbody," Technical Report 243, University of Delaware, June 1981.*

9. *Kayser, L.D., and Whiton, F., "Some Aerodynamic Characteristics of a Projectile Shape with a Nonaxisymmetric Boattail at Mach Numbers of 0.91 and 3.02," ARBRL-TR-02525, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, September 1983.*

10. *Schiff, L.B., and Sturek, W.B., "Numerical Simulation of Steady Supersonic Flow Over an Ogive Cylinder Boattail Body," ARBRL-TR-02363, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, September 1981 (AD A106060).*

II. EXPERIMENT

A. Models and Instrumentation

Details of the model geometry are shown in Figure 2. The three configurations tested had length to diameter (L/d) ratios of 6,7, and 8. The model was equipped with a boundary-layer trip for all test runs and was located 0.8 caliber from the nose tip. The trip was fabricated by spot welding two rows of 30 0.75mm steel balls to a thin ring. The trip ring can be seen in the photograph of Figure 1a. The models were mounted on a center body by means of ball bearing attachments; thus, the model was free to spin as aerodynamic torque was applied. The model was not equipped with the air driven turbine which is generally used for spinning axisymmetric shapes. The centerbody was mounted on an internal strain gage balance. A Naval Surface Weapons Center (NSWC) balance capable of measuring normal force, pitching moment, side force, and yawing moment was used for most of the test program. Since this balance did not have a drag measurement capability, a BRL balance was used for a limited number of test runs. The BRL balance had a smaller load capacity and for this reason, the angle-of-attack range and tunnel supply pressure were limited.

B. Wind Tunnels

The Mach 2.5, 3.5, and 5.0 tests were conducted in the NSWC Wind Tunnel No. 2. Tunnel No. 2 is a 0.41 x 0.41m (16 x 16 inch) cross-section horizontal tunnel with an open jet test section capable of operation over a Mach number range of 0.3 to 5.02 with supply pressures ranging from 0.5 to 15 atmospheres. The tunnel is capable of intermittent (blowdown) or continuous operation with a higher Reynolds number capability for the intermittent mode. Mach number changes are made by replacing the two-dimensional nozzle block units -- each nozzle block provides one distinct Mach number.

The Mach 6 portion of the test program was conducted in the NSWC Wind Tunnel No. 8 which has a Mach number range of 5 to 10. The Mach 6 nozzle is two dimensional and has a nozzle exit size of 0.46 x 0.46 m (18 x 18 inches). A pebble bed heater and an electric resistance heater are used to heat the air so that air liquefaction in the expanding nozzle is avoided. The tunnel is operated only in the intermittent mode but the run time can be substantial for high Mach numbers and low supply pressures. Air is stored in a high pressure bottle field and can be supplied to the tunnel at pressures up 150 atmospheres.

C. Test Procedure

Data were acquired at the conditions shown in the test run summary of Table 1. The procedure for acquiring data was to start the tunnel, pitch the model to the desired attitude, let the model spin rate stabilize, and then record the data. At each angle of attack, numerous (approx. 30) sets of data were recorded and then averaged to provide one useful set of data for each angle of attack. Normal force, pitching moment, side force, and yawing moment data were adjusted so that the data curve, as a function of angle of attack, passed through the origin. For the purpose of computing pitching moment and yawing moment data, the center of gravity was assumed to be located at 60% of the model length from the nose.

III. RESULTS

A tabulation of the coefficient data is provided in the appendix. The dimensionless spin rates for zero angle of attack are shown in Figure 3 along with the "match-spin" rate. There does seem to be some Mach number dependence on spin rate with the spin rate at the lower Mach numbers approaching the "match-spin" rate. Also, the higher Reynolds number flow produces a higher rate than the lower Reynolds flow. The higher Reynolds flow was achieved primarily by increasing the density; therefore, the dynamic pressure is approximately proportional to the Reynolds number. The increase in spin rate could be due to: (1) a Reynolds effect, (2) an increase in dynamic pressure overcoming bearing friction or (3) a combination of 1 and 2. For this reason, the change in spin rate with Reynolds number is believed to be partly the result of bearing friction. In a free flight situation, the spin rate at launch would equal "match-spin" and as the velocity decays, the spin rate would also decay but would always be slightly above "match-spin." To determine the effects of bearing friction, a spin control system, such as an air turbine drive, would be needed so that spin rates could be adjusted both above and below "match-spin."

Static stability characteristics of the semicorkscrew projectile are presented in Figures 4a to 4g. Figures 4a to 4d are normal force and center of pressure plots. The normal force curves show, as expected, that the longer configurations have the larger normal force. The center of pressure data are in calibers from the c.g. which is assumed to be located at 60% of the model length from the nose. The positive values of X_{cp} show that all configurations are statically unstable and are most unstable at zero angle of attack. The static behavior is summarized in Figures 4e, f, g where C_{N_α}, C_{m_α}, and X_{cp} are shown as a function Mach number. The slope of the normal force does not show a large variation for the different model lengths. Values of C_{m_α} show the instability for all configurations over the range of Mach numbers tested. Values of C_{m_α} and X_{cp} are relatively constant over the Mach number range and show that instability increases with increasing model length. Reference 7 compares results for a 6.2 caliber nonconical boattail configuration with axisymmetric shapes having the same L/d. The nonconical configuration (of Reference 7) had a conventional axisymmetric forebody and a boattail identical to the semicorkscrew boattail; this configuration was designated "Projectile A." The results of Reference 7 show a substantial increase in stability with the addition of the nonconical boattail. A value of C_{m_α} of 0.29 at $M = 3$ is nearly equal to that of the 6-caliber semicorkscrew shape. This comparison suggests that the improvement in stability is primarily a result of the nonconical boattail and not of the forward facing flat (helical) surfaces.

The axial force, excluding base drag, data shown in Figures 5a to 5c are somewhat erratic. Generally, the longer configuration has the larger axial force and the force decreases with increasing Mach number.

A sample of side force and yawing moment data are shown in Figures 6a and 6b. The data are somewhat erratic and the yawing moment is seen to be highly

nonlinear. To the extent possible, slopes of the side force and yawing moment coefficients at zero angle of attack were obtained and are shown in Figures 6c and 6d. The slope of the side force coefficient is negative, which is typical for axisymmetric projectiles, but the slope of the yawing moment coefficient is also negative, which is not typical for axisymmtric projectiles. This indicates that the dominant portion of the side force is forward of the c.g. whereas the typical Magnus center of pressure is aft of the c.g. Since the model spin rate could be varied, the influence of bearing friction could not be determined. If the model is slowed by bearing friction, the twisted surfaces will act similar to canted fins, thus affecting side force and yawing moment data by an unknown amount. However, if there is a canted fin effect, it must be small since the side forces and yawing moments are of the same order of magnitude as those for axisymmetric shapes.

IV. CONCLUSIONS

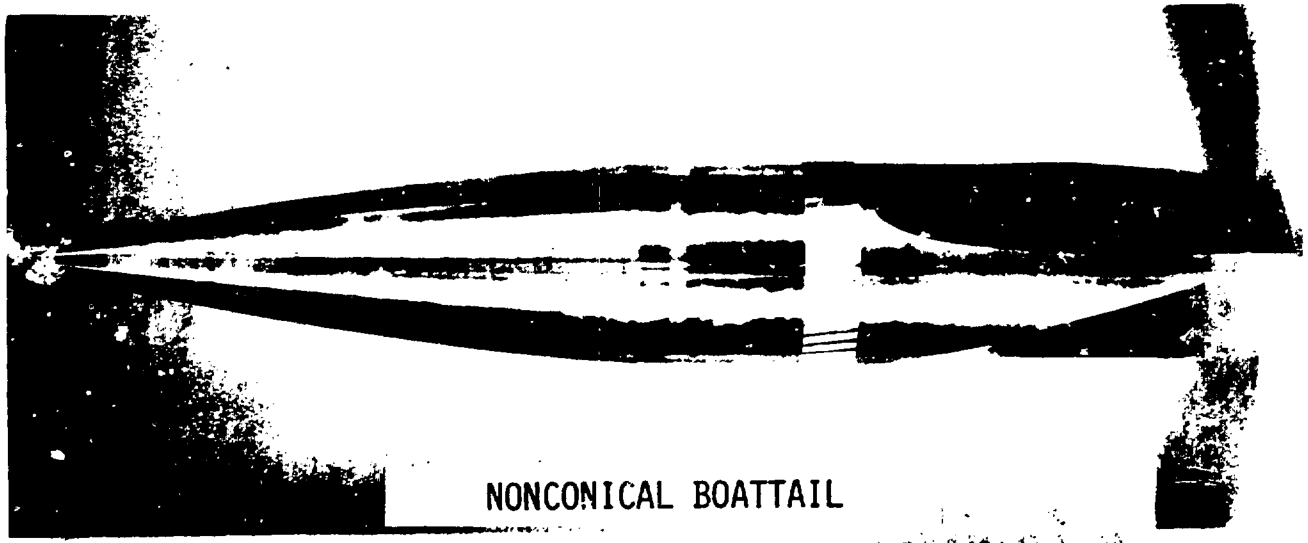
1. The normal force, pitching moment and axial force measurements provide a data base that will be useful in evaluating computational results for nonaxisymmetric projectile shapes.

2. Comparisons of the side force and yawing moment data with computations should be made with reservation due to the unknown effects of bearing friction.

3. The shorter (L/d = 6) semicorkscrew shape is considerably more stable than a typical axisymmetric shape but is not noticeably more stable than a nonconical boattail shape of comparable length. Instability of the semicorkscrew shape increases with increasing length.

Figure 1. Projectile Photographs

a. Semicorkscrew Model

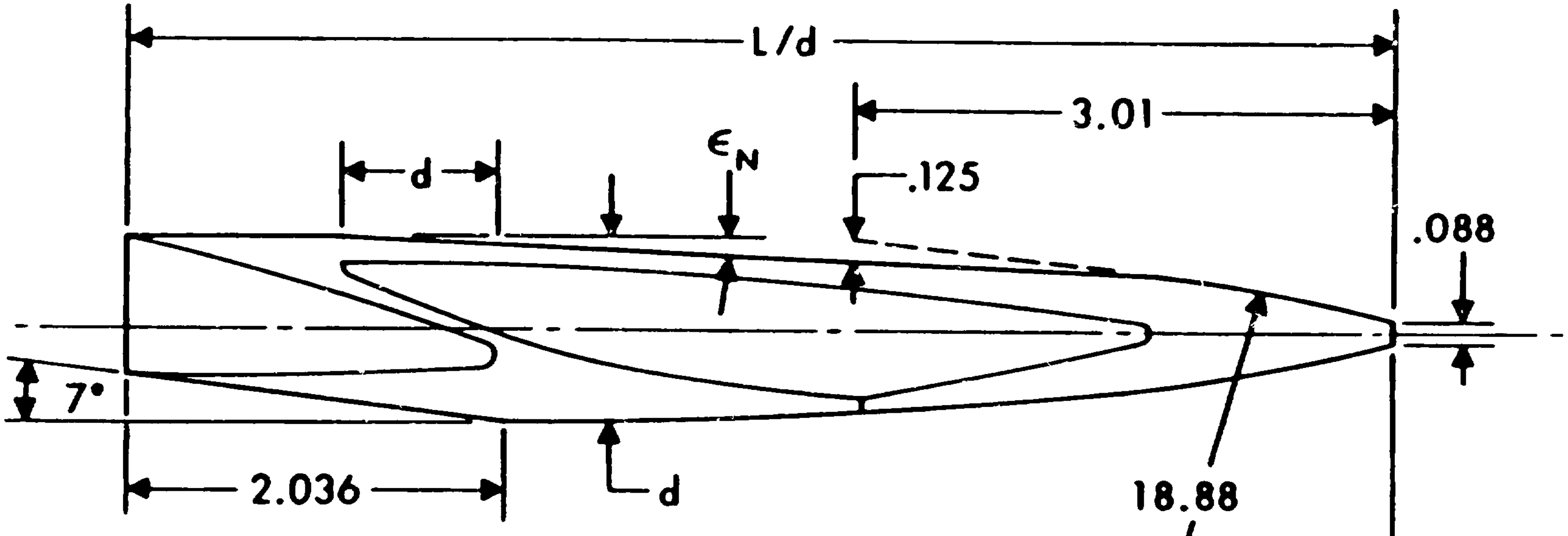


NONCONICAL BOATTAIL

CORKSCREW

Figure 1. Continued

b. Nonconical Boattail and Corkscrew Shapes



$$\tan \epsilon_N = \frac{.125}{L/d - 3.01 - 2.036 + 1}$$

L/d	5.0	5.5	6.0	6.5	7.0	7.5	8.0
ϵ_N	7.13°	4.91°	3.66°	2.92°	2.42°	2.07°	1.81°

Figure 2. Semicorkscre Geometry

SEMICORKSCREW

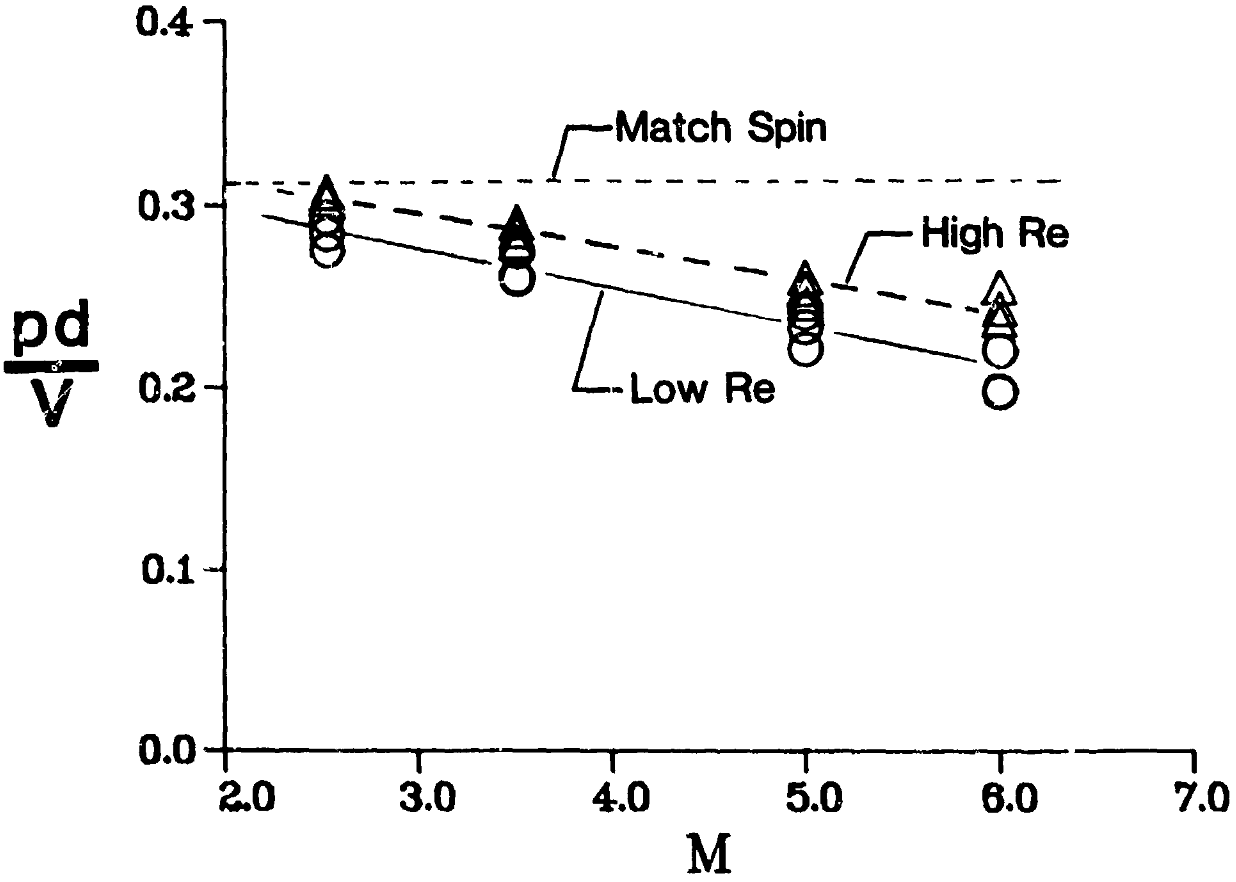


Figure 3. Dimensionless Spin Rate, pd/V, α = 0

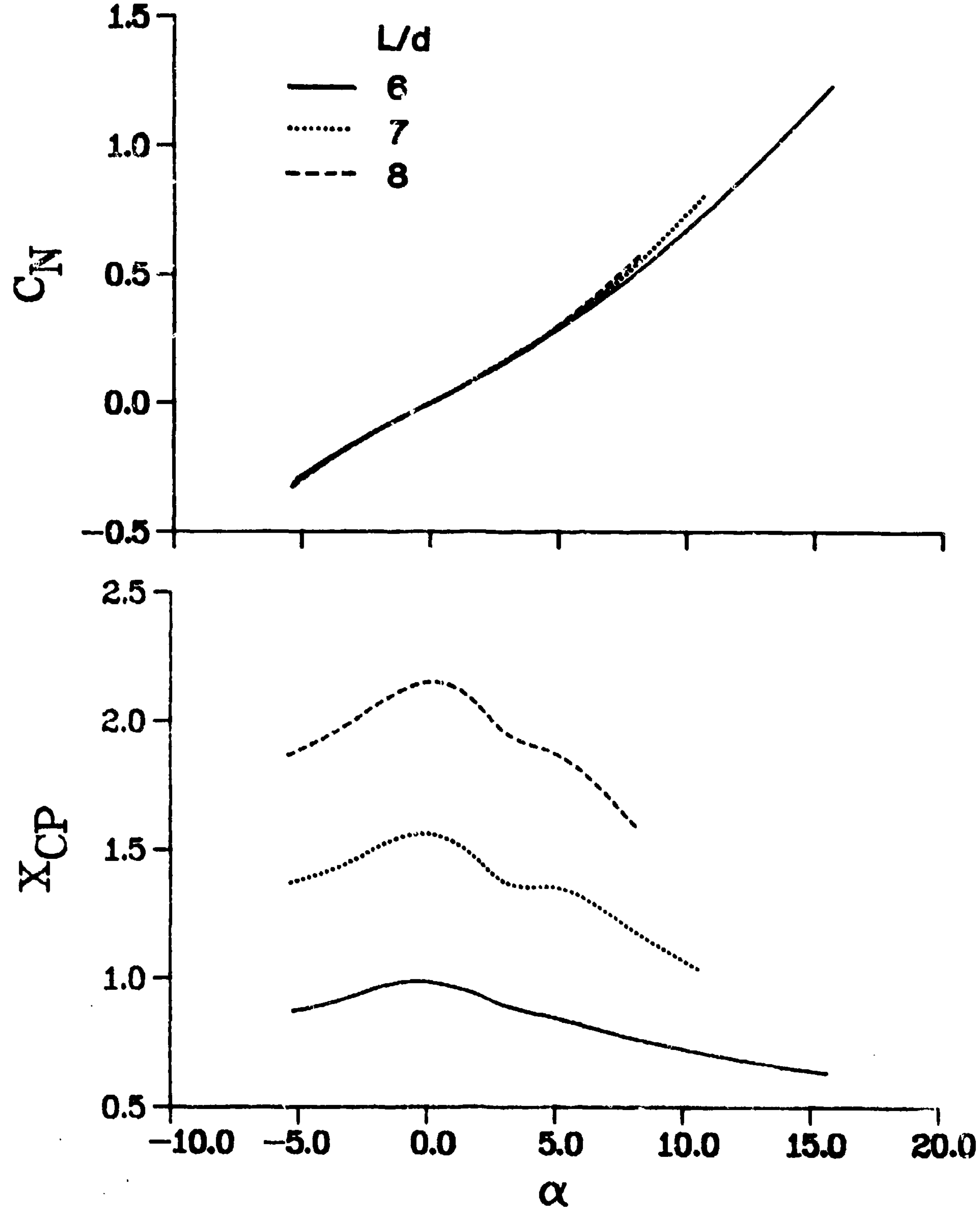


Figure 4. Static Stability

a. C_N and X_{cp} vs α, $M = 2.53$, $P_o = 172$ kPa

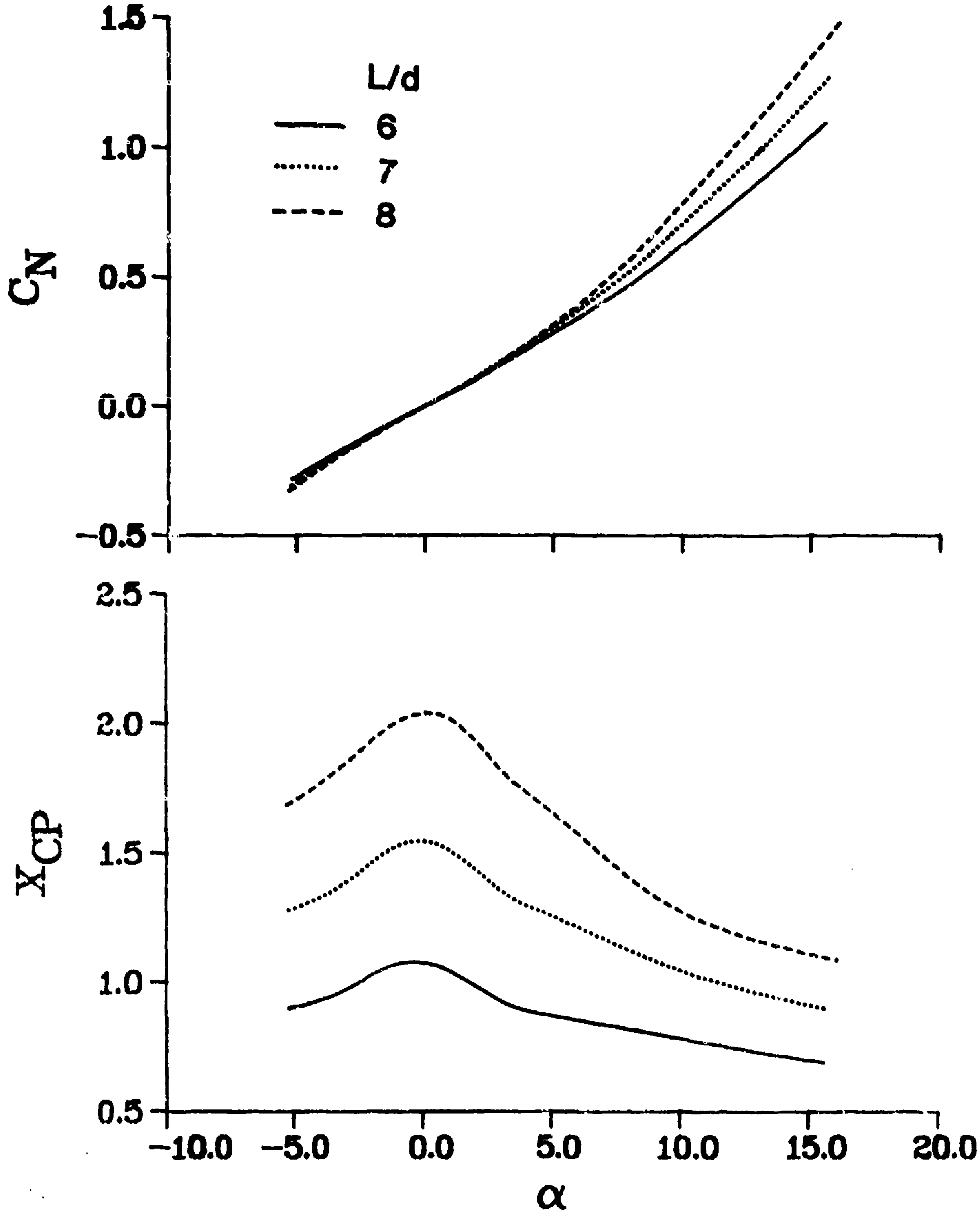


Figure 4. Continued

b. C_N and X_{cp} vs α, M = 3.51, P_o = 276 kPa

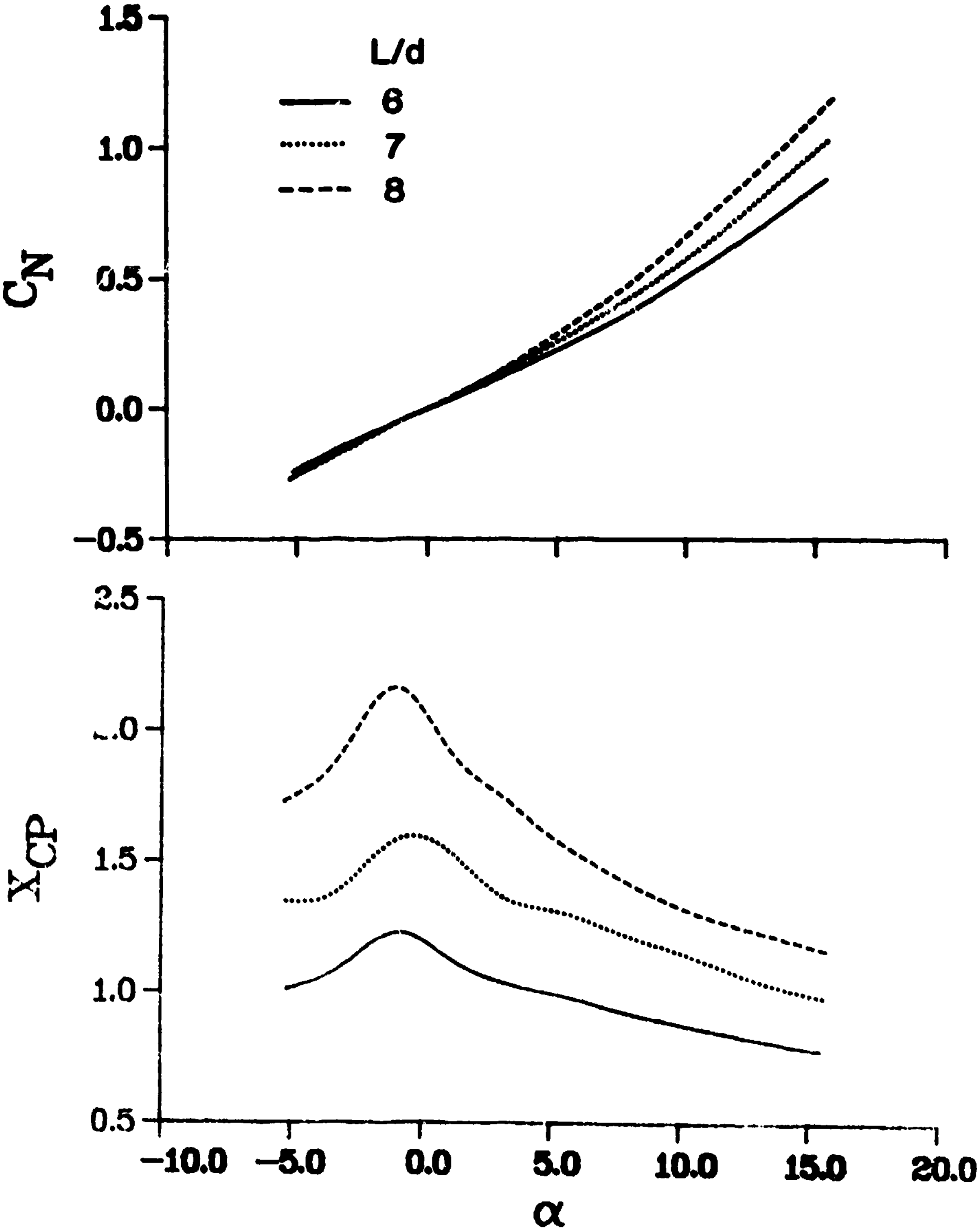


Figure 4. Continued

c. C_N and X_{cp} vs α, M = 5.00, P_o = 827 kPa

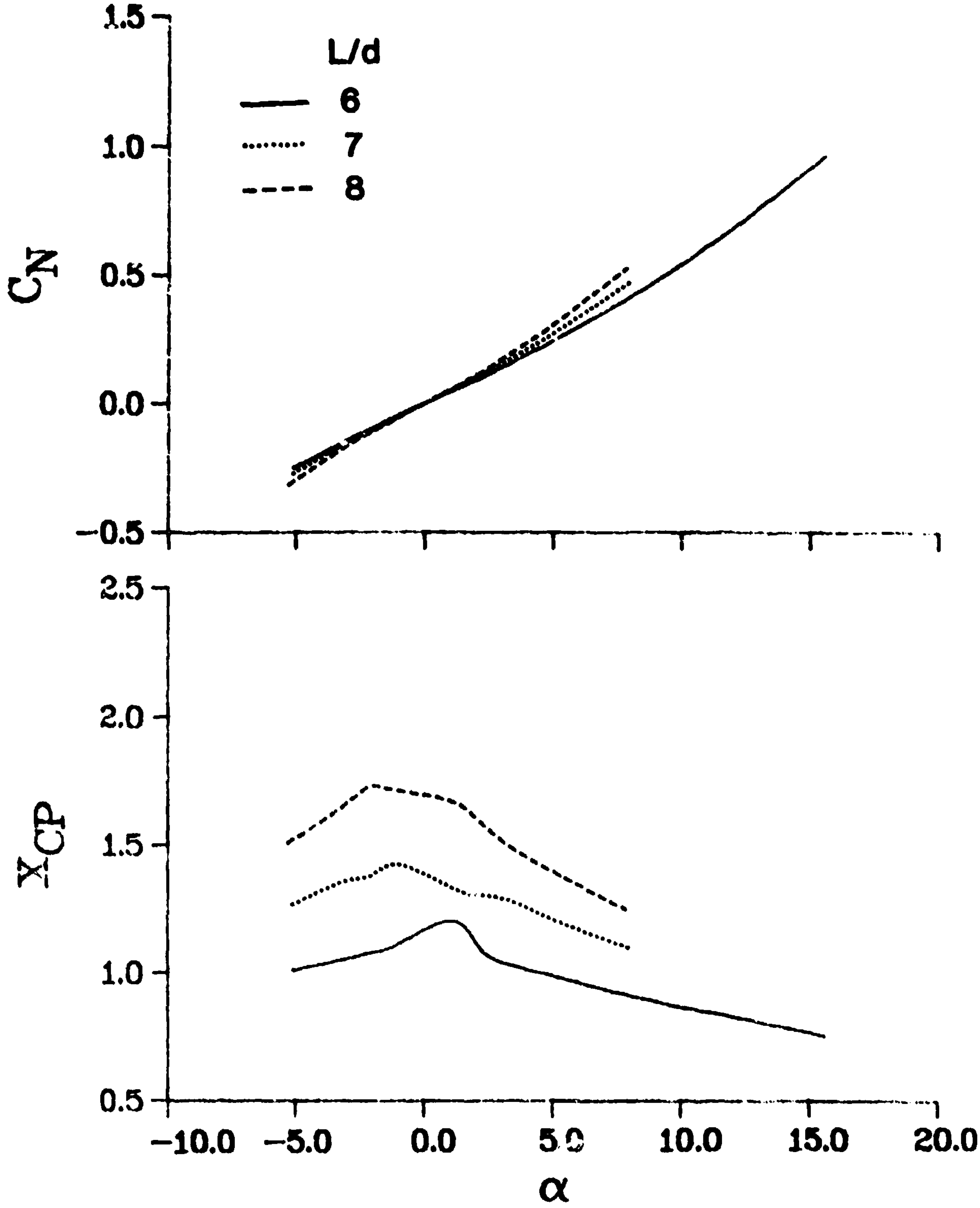


Figure 4. Continued

d. C_N and X_{cp} vs α, M = 6.00, P_0 = 1931 kPa

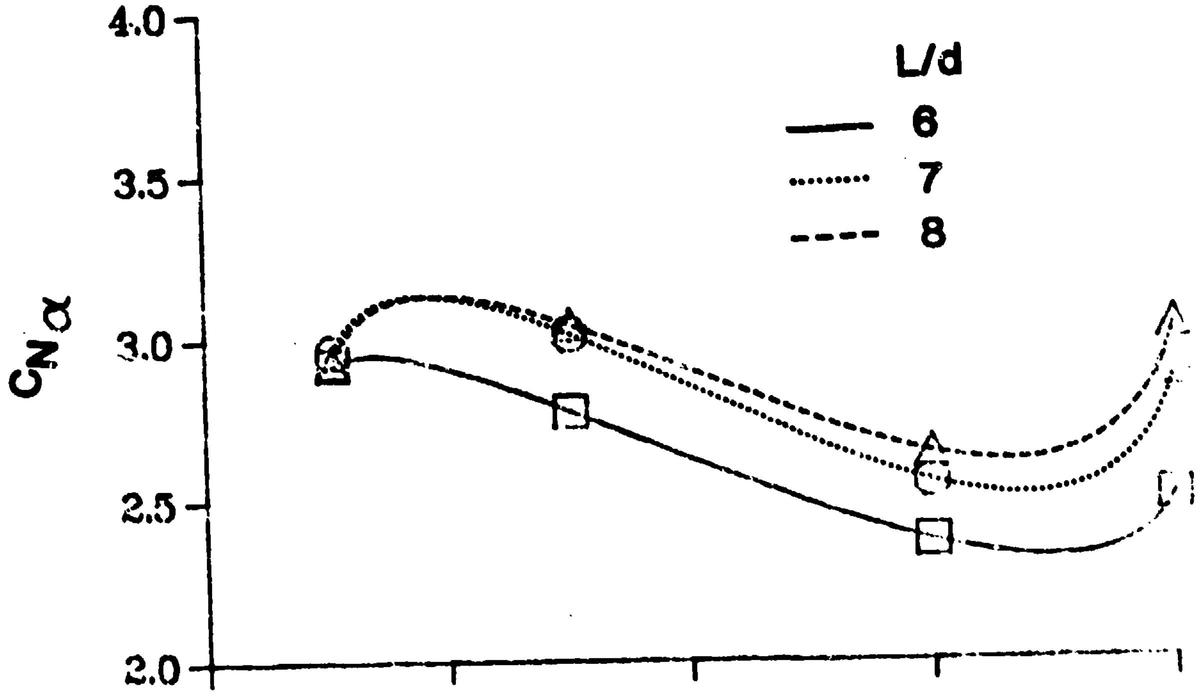


Figure 4. Continued

e. C_{N_α} vs M

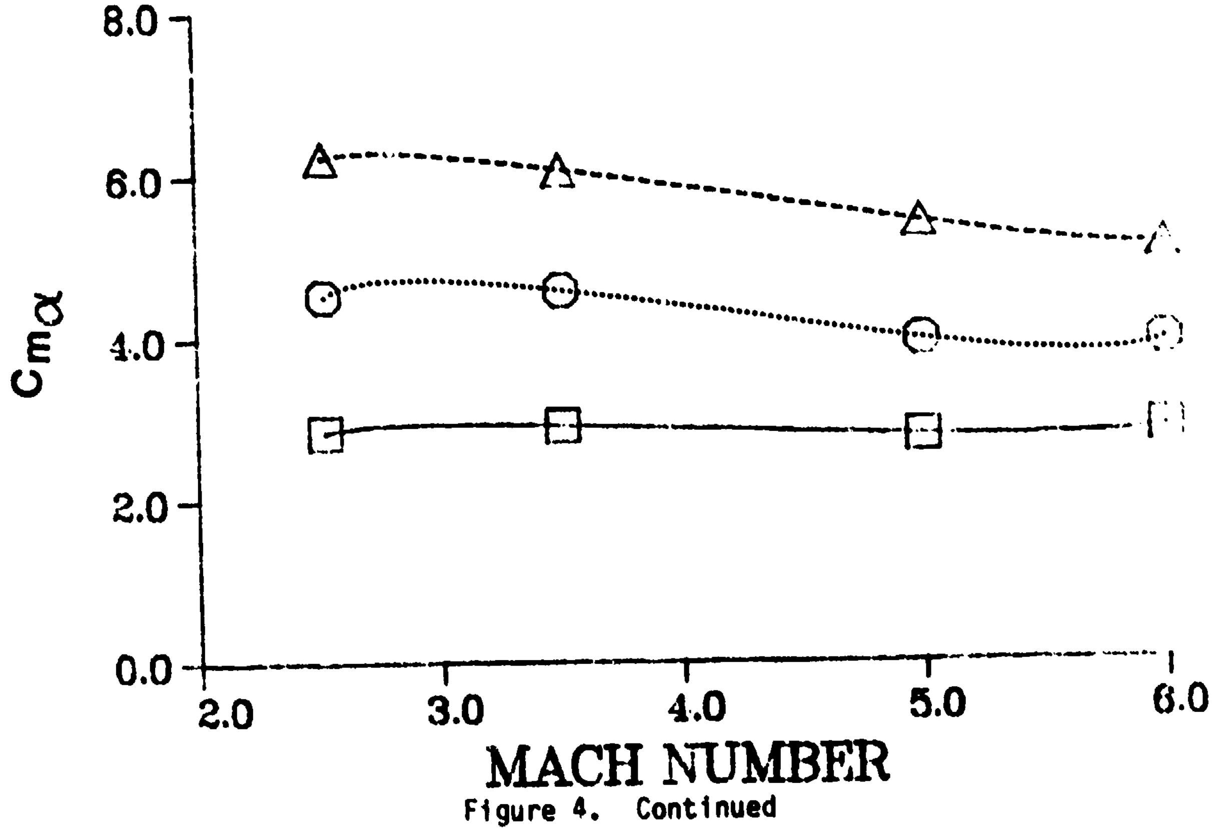


Figure 4. Continued

f. C_{m_α} vs M

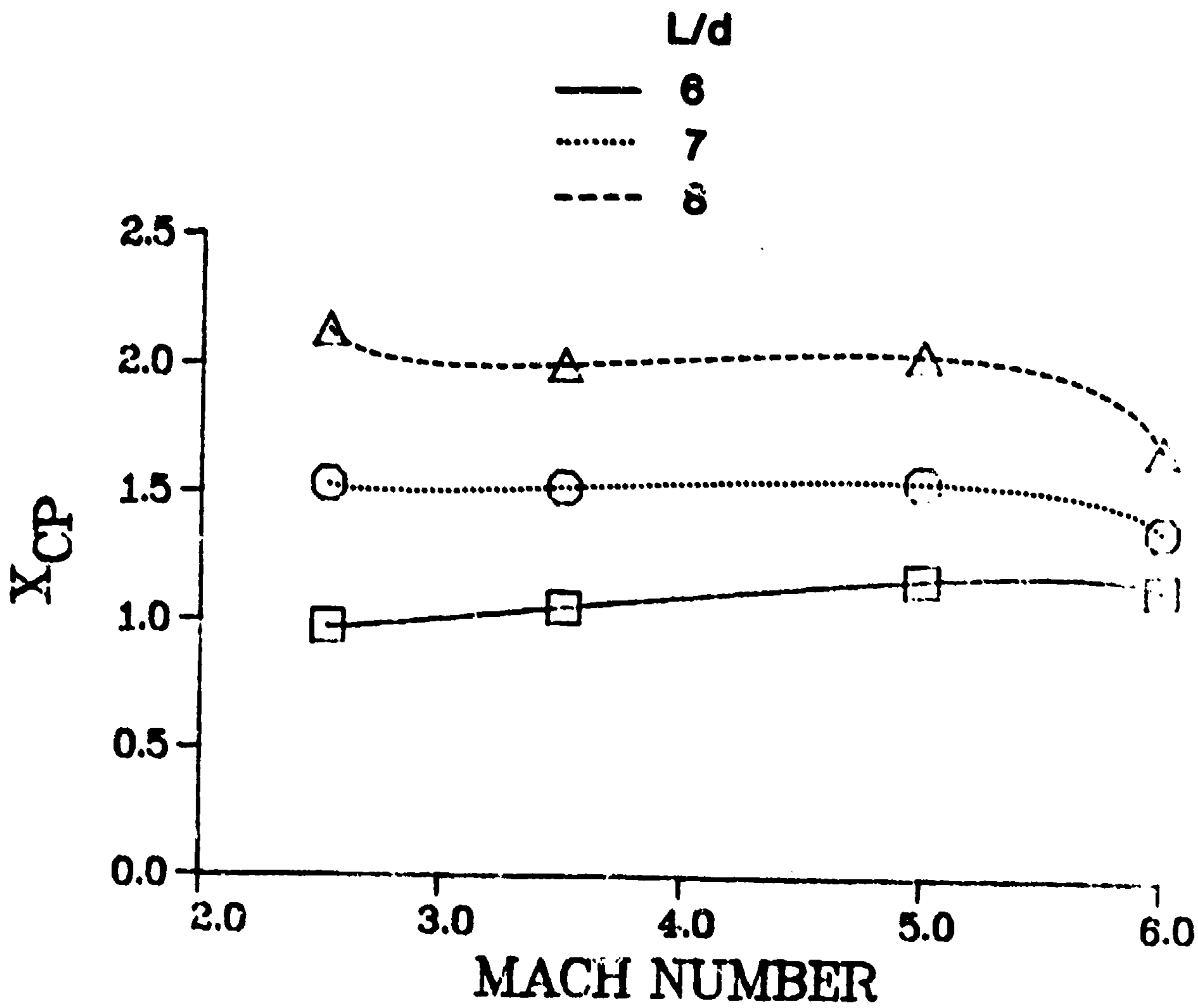


Figure 4. Continued

g. X_{cp} vs M

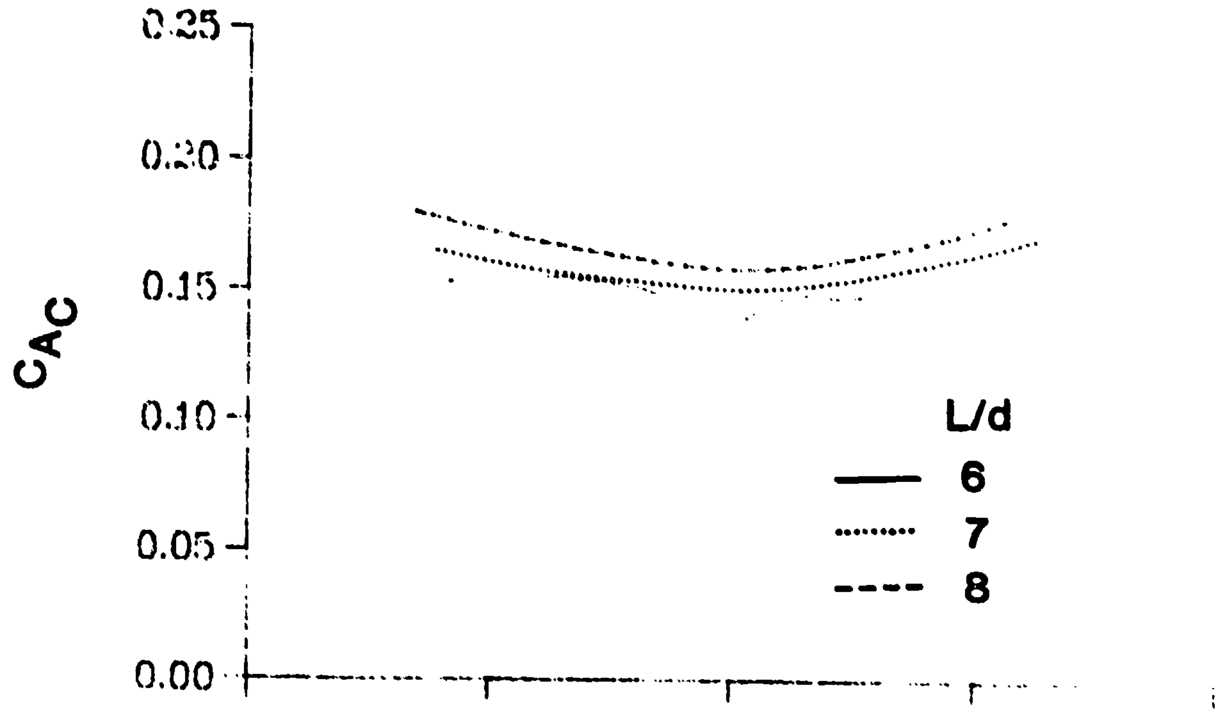


Figure 5. Axial Force

a. M = 2.53, P_o = 172 kPa

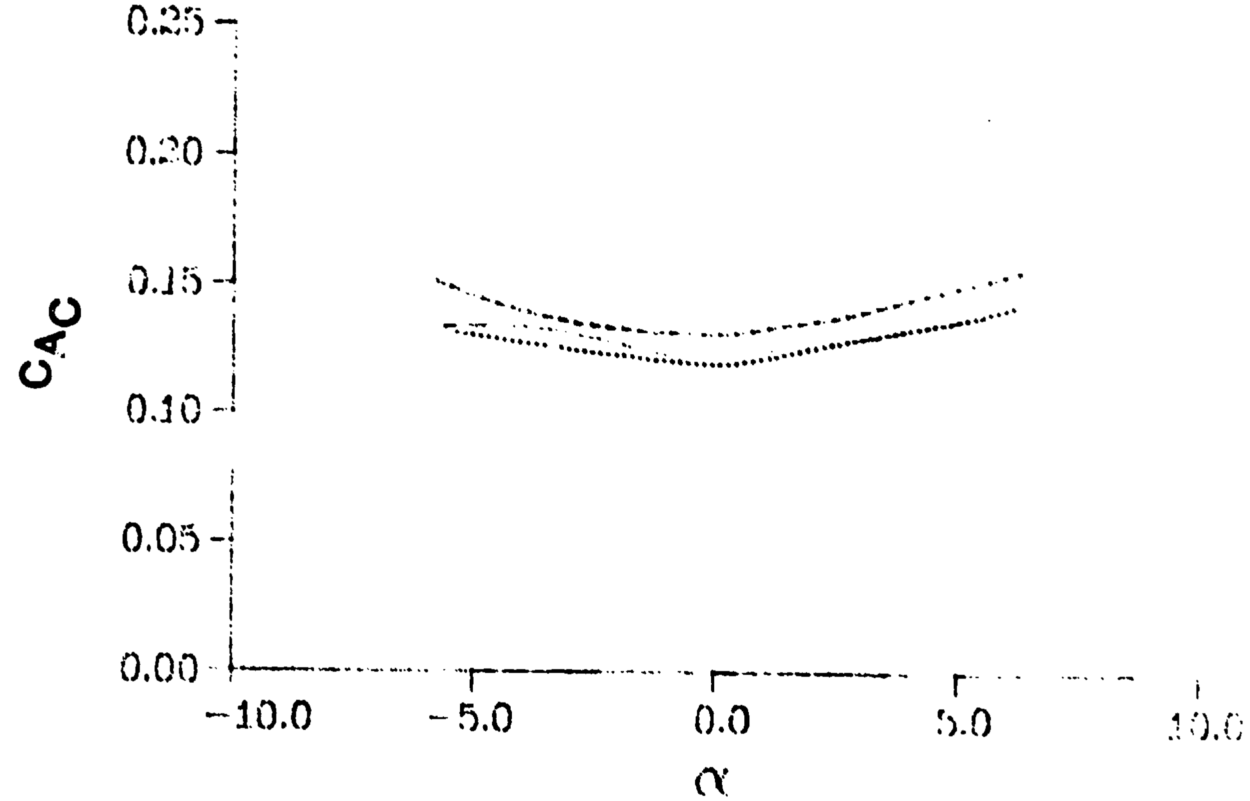


Figure 5. Continued

b. M = 3.51, P_o = 276 kPa

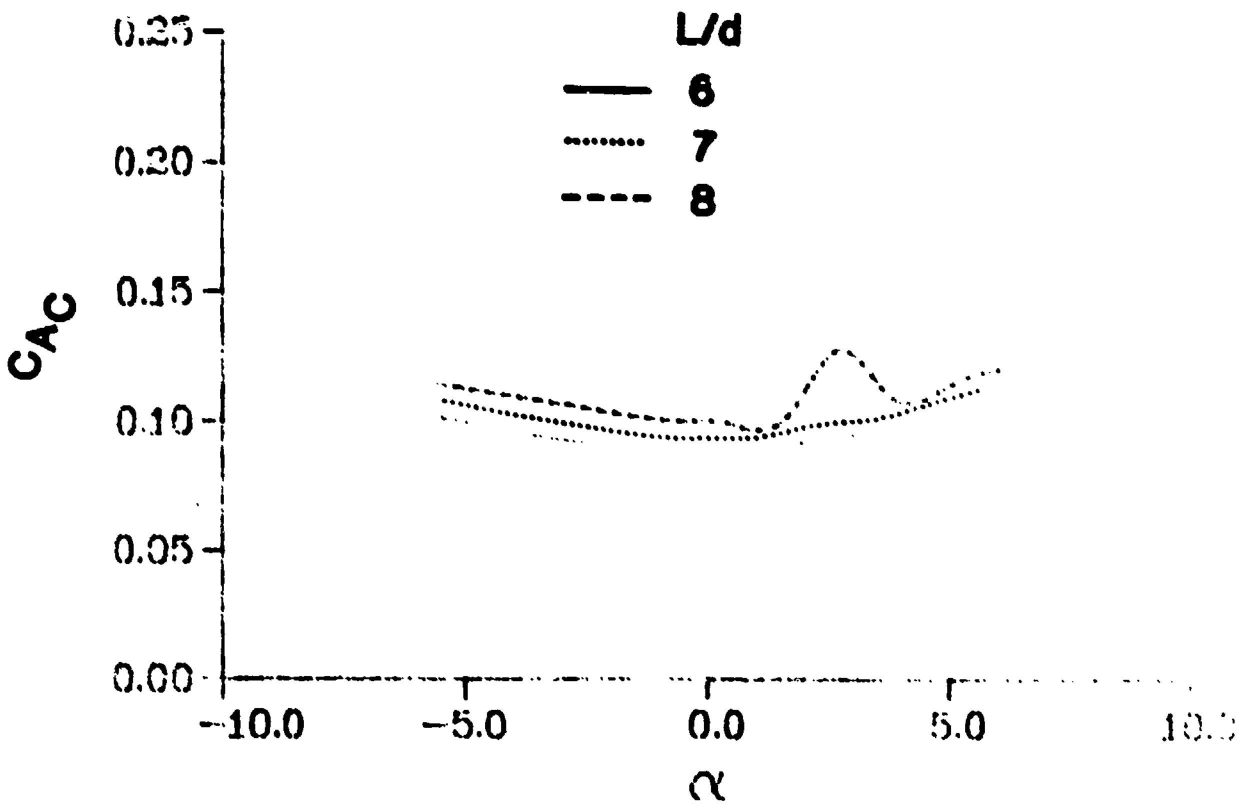


Figure 5. Continued

c. M = 5.00, P_0 = 827 kPa

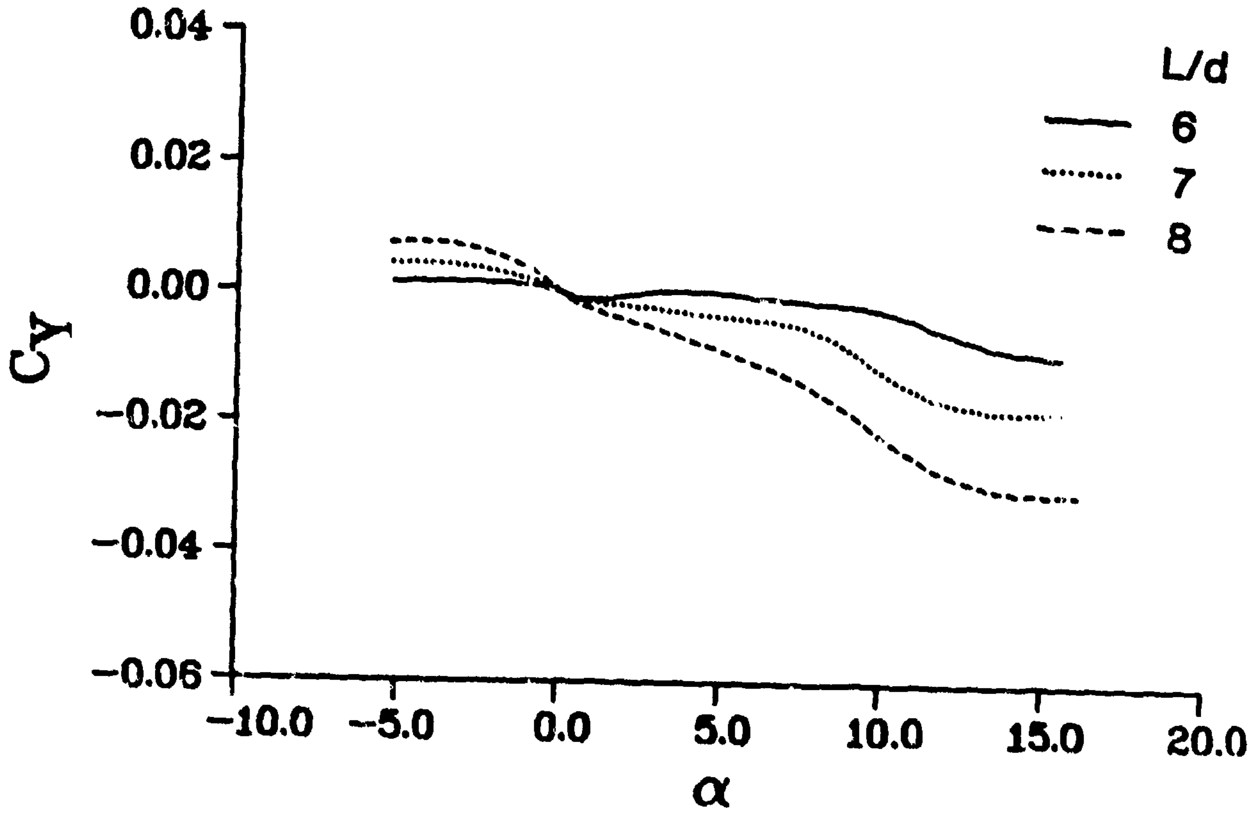


Figure 6. Lateral Forces and Moments

a. C_y vs α

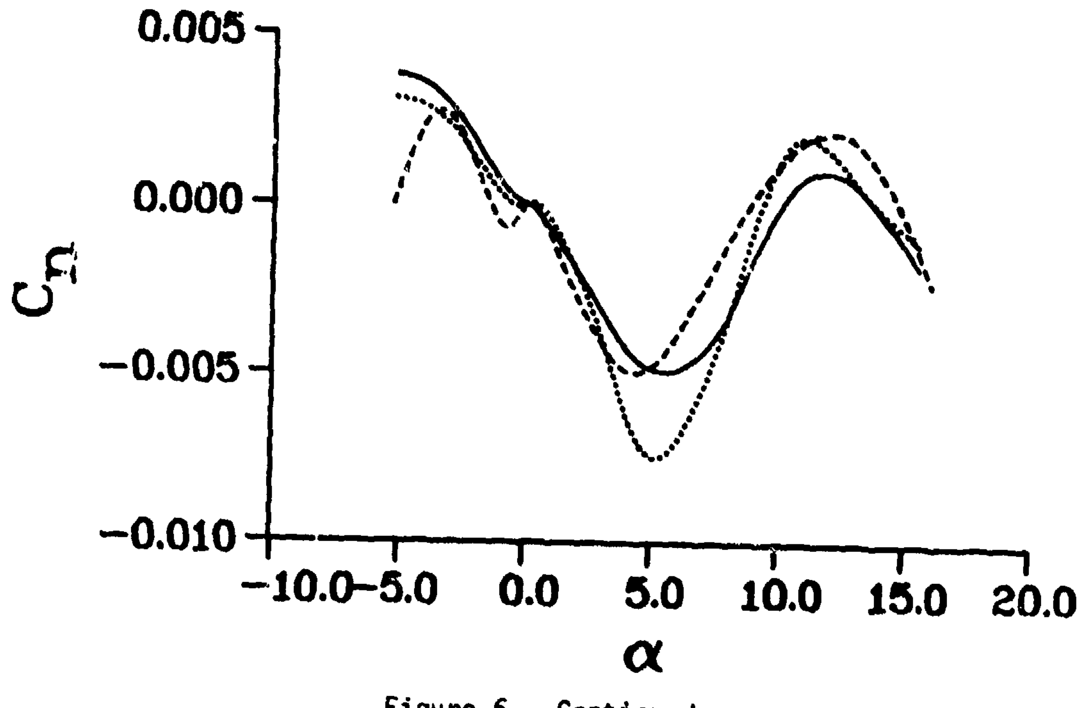


Figure 6. Continued

b. C_n vs α

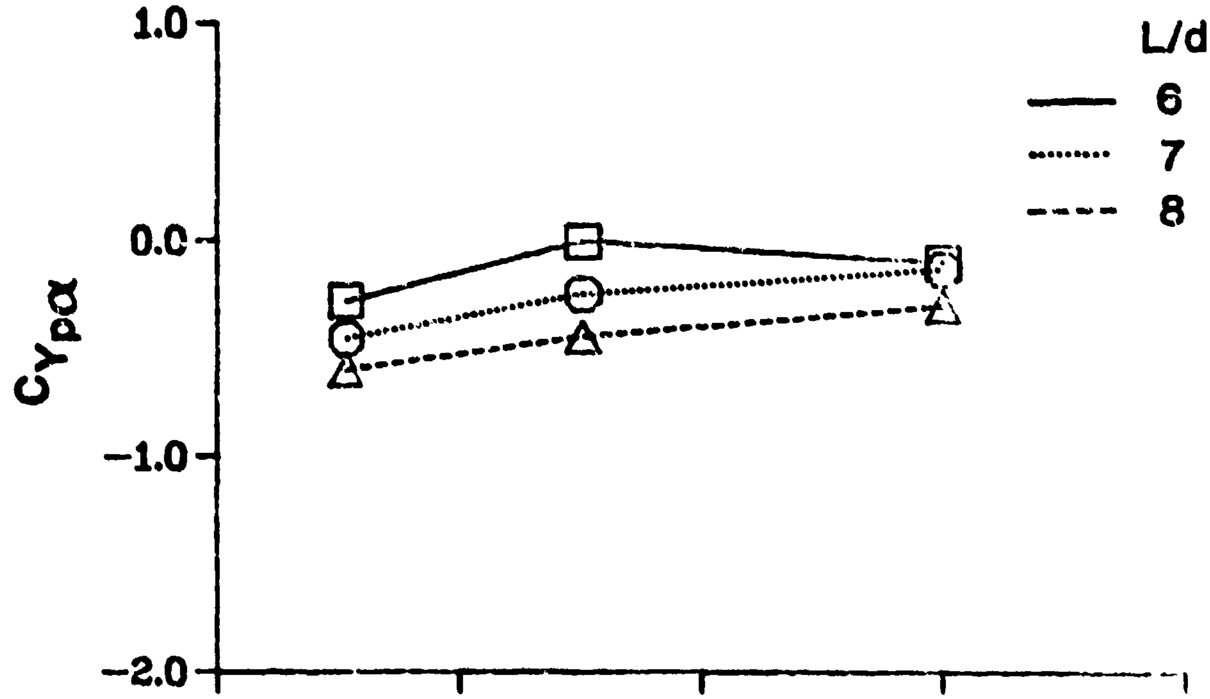


Figure 6. Continued

c. $C_{y_{p\alpha}}$ vs M

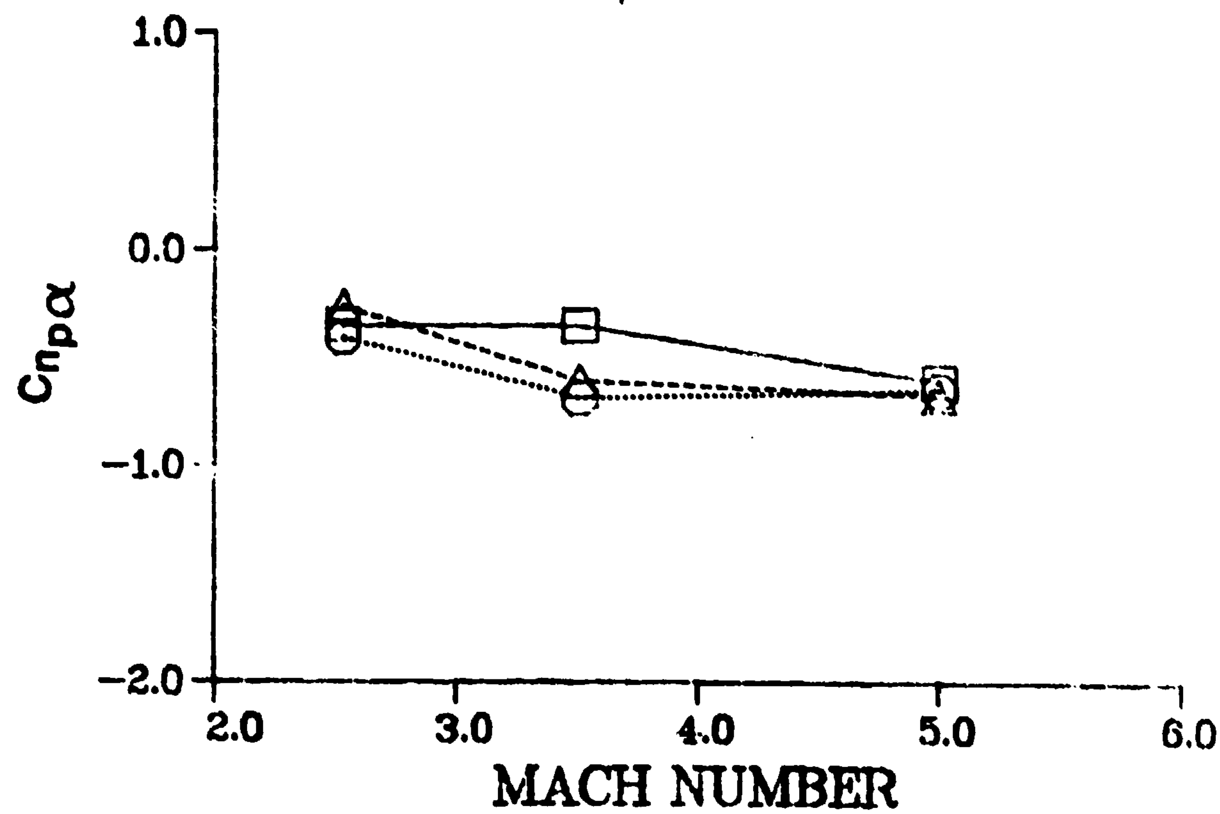


Figure 6. Continued

d. $C_{n_{p\alpha}}$ vs M

TABLE 1. TEST RUN SUMMARY

M	L/d	$Re_\ell \times 10^6$	P_0, kPA	T_0, k	α, deg	balance
2.53	6	6.3	172	294	-5 to 15	NSWC
	7	7.3			-5 to 10	
	8	8.3			-5 to 8	
3.51	6	6.3	276	294	-5 to 15	
	7	7.3				
	8	8.3				
5.00	6	6.3	827	367	-5 to 15	
	7	7.3				
	8	8.3				
6.00	6	6.3	1931	478	-5 to 15	
	7	7.3			-5 to 7.5	
	8	8.3			-5 to 7.5	
2.53	6	11.3	310	294	-3 to 10	
	7	13.1			-3 to 9	
	8	15.0			-3 to 9	
3.51	6	11.3	517	294	-5 to 15	
	7	13.1			-5 to 13	
	8	15.0			-5 to 10	
5.00	6	11.3	1517	367	-5 to 15	
	7	13.1			-5 to 15	
	8	15.0			-5 to 10	
6.00	6	11.3	3448	478	-5 to 10	
	7	13.1			-5 to 7.5	
	8	15.0			-5 to 7.5	
2.53	6	6.3	172	294	-5 to 5	BRL
	7	7.3				
	8	8.3				
3.51	6	6.3	276	294	-5 to 5	
	7	7.3				
	8	8.3				
5.00	6	6.3	827	367	-5 to 5	
	7	7.3				
	8	8.3				

REFERENCES

1. Platou, A.S., "An Improved Projectile Boattail," ARBRL-MR-2395, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, July 1974 (AD 785520).

2. Platou, A.S., and Nielson, G.I.T., "An Improved Projectile Boattail. Part II.," BRL R 1866, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, March 1976 (AD A024073).

3. Platou, A.S., "An Improved Projectile Boattail. Part III.," ARBRL-MR-2644, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, July 1976 (AD B012781L).

4. Platou, A.S., "An Improved Projectile Boattail. Part IV.," ARBRL-MR-02826, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, April 1978 (AD B027520L).

5. Platou, A.S., "Aeroballistics of Corkscrew Projectiles," ARBRL-MR-02825, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, April 1978 (AD A054735).

6. Platou, A.S., "Decreasing the Flight Time of Bullets by Improving Its Aerodynamic Characteristics," ARBRL-MR-03103, U.S. Ar Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, May 1981 (AD B058203L).

7. Kayser, L.D., and Sturek, W.B., "Aerodynamic Performance of Projectiles with Axisymmetric and Non-Axisymmetric Boattails," ARBRL-MR-03022, U.S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, May 1980 (AD A086091)

8. Danberg, J.E., and Tschirschnitz, R.H., "Transonic Pressure Distribution and Boundary Layer Characteristics of a Projectile with an Asymmetric Afterbody," Technical Report 243, University of Delaware, June 1981.

9. Kayser, L.D., and Whiton, F., "Some Aerodynamic Characteristics of a Projectile Shape with a Nonaxisymmetric Boattail at Mach Numbers of 0.91 and 3.02," ARBRL-TR-02525, U. S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, September 1983.

10. Schiff, L.B. and Sturek, W.B., "Numerical Simulation of Steady Supersonic Flow Over an Ogive Cylinder Boattail Body," ARBRL-TR-02363, U. S. Army Ballistic Research Laboratory, ARRADCOM, Aberdeen Proving Ground, Maryland 21005, September 1981 (AD A106060).

APPENDIX A

TABULATED DATA

APPENDIX A - TABULATED DATA

TABLE OF CONTENTS

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	2.53	6.25	-5.20	0.281	-0.293	-0.256	0.0046	0.0028	0.87
6	2.53	6.38	-3.25	0.284	-0.173	-0.159	0.0036	0.0030	0.92
6	2.53	6.38	-1.09	0.276	-0.054	-0.053	0.0017	0.0012	0.98
6	2.53	6.38	0.01	0.275	0.001	0.001	0.0000	0.0000	
6	2.53	6.38	1.07	0.277	0.056	0.054	-0.0020	-0.0013	0.97
6	2.53	6.50	3.17	0.284	0.171	0.153	-0.0042	-0.0041	0.89
6	2.53	6.50	5.26	0.297	0.306	0.257	-0.0050	-0.0082	0.84
6	2.53	6.38	7.85	0.305	0.493	0.381	-0.0056	-0.0106	0.77
6	2.53	6.38	10.48	0.305	0.717	0.514	-0.0067	-0.0094	0.72
6	2.53	6.38	13.16	0.304	0.971	0.650	-0.0109	-0.0045	0.67
6	2.53	6.38	15.65	0.308	1.232	0.781	-0.0134	-0.0052	0.63
7	2.53	7.58	-5.30	0.292	-0.309	-0.424	0.0081	-0.0006	1.37
7	2.53	7.58	-3.15	0.295	-0.172	-0.248	0.0062	0.0021	1.44
7	2.53	7.44	-1.04	0.289	-0.053	-0.082	0.0026	0.0005	1.55
7	2.53	7.56	0.04	0.284	0.002	0.003	-0.0001	0.0000	
7	2.53	7.58	1.11	0.284	0.058	0.088	-0.0031	-0.0008	1.53
7	2.53	7.58	3.18	0.288	0.180	0.246	-0.0073	-0.0037	1.37
7	2.53	7.58	5.30	0.297	0.318	0.428	-0.0107	-0.0045	1.35
7	2.53	7.58	7.98	0.308	0.536	0.639	-0.0155	-0.0036	1.19
7	2.53	7.58	10.64	0.310	0.803	0.831	-0.0214	0.0011	1.03
8	2.53	8.67	-5.38	0.301	-0.322	-0.601	0.0134	-0.0063	1.87
8	2.53	8.50	-3.22	0.304	-0.177	-0.349	0.0086	0.0003	1.96
8	2.53	8.67	-1.07	0.299	-0.055	-0.116	0.0042	-0.0006	2.11
8	2.53	8.67	0.07	0.293	0.004	0.008	-0.0003	0.0000	
8	2.53	8.67	1.10	0.294	0.056	0.120	-0.0040	0.0007	2.13
8	2.53	8.67	3.22	0.299	0.180	0.350	-0.0100	-0.0020	1.95
8	2.53	8.67	5.40	0.306	0.331	0.613	-0.0174	-0.0039	1.85
8	2.53	8.67	8.23	0.316	0.582	0.922	-0.0278	0.0026	1.58

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	3.51	6.50	-5.15	0.291	-0.279	-0.252	0.0013	0.0038	0.90
6	3.51	6.50	-3.12	0.288	-0.160	-0.154	0.0015	0.0030	0.97
6	3.51	6.38	-1.03	0.279	-0.050	-0.053	0.0010	0.0007	1.07
6	3.51	6.50	0.03	0.275	0.001	0.002	0.0000	0.0000	
6	3.51	6.50	1.06	0.274	0.051	0.053	-0.0011	-0.0008	1.04
6	3.51	6.50	3.11	0.280	0.166	0.154	0.0001	-0.0032	0.93
6	3.51	6.50	5.18	0.287	0.292	0.254	-0.0001	-0.0049	0.87
6	3.51	6.50	7.79	0.292	0.459	0.379	-0.0012	-0.0036	0.82
6	3.51	6.50	10.32	0.292	0.650	0.505	-0.0029	0.0003	0.78
6	3.51	6.50	12.95	0.292	0.864	0.633	-0.0073	0.0007	0.73
6	3.51	6.50	15.58	0.293	1.095	0.758	-0.0094	-0.0018	0.69
7	3.51	7.44	-5.20	0.272	-0.305	-0.390	0.0042	0.0031	1.28
7	3.51	7.44	-3.13	0.272	-0.172	-0.236	0.0039	0.0024	1.38
7	3.51	7.44	-1.00	0.264	-0.052	-0.080	0.0019	0.0003	1.53
7	3.51	7.58	0.04	0.259	0.002	0.003	-0.0001	0.0000	
7	3.51	7.58	1.04	0.259	0.055	0.083	-0.0015	-0.0005	1.51
7	3.51	7.44	3.13	0.264	0.179	0.242	-0.0026	-0.0041	1.35
7	3.51	7.58	5.24	0.273	0.320	0.399	-0.0037	-0.0075	1.25
7	3.51	7.44	7.97	0.279	0.525	0.591	-0.0058	-0.0035	1.13
7	3.51	7.44	10.42	0.283	0.744	0.766	-0.0132	0.0018	1.03
7	3.51	7.44	13.08	0.286	0.995	0.953	-0.0175	0.0007	0.96
7	3.51	7.58	15.72	0.287	1.273	1.142	-0.0177	-0.0012	0.90
8	3.51	8.17	-5.27	0.261	-0.325	-0.549	0.0073	0.0000	1.69
8	3.51	8.17	-3.17	0.265	-0.180	-0.329	0.0071	0.0027	1.83
8	3.51	8.33	-1.09	0.263	-0.059	-0.117	0.0038	-0.0005	2.00
8	3.51	8.33	-0.03	0.260	-0.002	-0.003	0.0001	0.0000	
8	3.51	8.33	1.08	0.260	0.056	0.113	-0.0028	-0.0011	2.02
8	3.51	8.33	3.13	0.265	0.181	0.328	-0.0058	-0.0042	1.82
8	3.51	8.33	5.31	0.275	0.337	0.553	-0.0094	-0.0046	1.64
8	3.51	8.33	8.01	0.284	0.576	0.810	-0.0150	-0.0011	1.41
8	3.51	8.50	10.61	0.291	0.840	1.05[illegible]	-0.0239	0.0017	1.25
8	3.51	8.33	13.37	0.292	1.156	1.332	-0.0296	0.0017	1.15
8	3.51	8.33	16.11	0.293	1.479	1.505	-0.0304	-0.0023	1.09

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	5.00	7.13	-5.13	0.240	-0.239	-0.242	0.0020	0.0029	1.01
6	5.00	7.25	-3.10	0.242	-0.137	-0.150	0.0014	0.0038	1.09
6	5.00	7.38	-1.01	0.237	-0.043	-0.053	0.0006	0.0008	1.23
6	5.00	7.25	0.01	0.233	0.000	0.001	0.0000	0.0000	
6	5.00	7.38	1.07	0.234	0.043	0.048	-0.0009	-0.0006	1.13
6	5.00	7.38	3.17	0.239	0.138	0.143	-0.0009	-0.0021	1.03
6	5.00	7.38	5.15	0.243	0.231	0.230	-0.0009	-0.0005	0.99
6	5.00	7.38	7.75	0.246	0.368	0.341	-0.0046	0.0035	0.93
6	5.00	7.38	10.25	0.250	0.524	0.459	-0.0099	0.0063	0.88
6	5.00	7.25	12.85	0.258	0.697	0.575	-0.0105	0.0074	0.83
6	5.00	7.25	15.45	0.263	0.883	0.691	-0.0113	0.0096	0.78
7	5.00	8.31	-5.21	0.226	-0.264	-0.354	0.0005	0.0021	1.34
7	5.00	8.31	-3.22	0.228	-0.160	-0.222	0.0017	0.0027	1.39
7	5.00	8.31	-1.09	0.225	-0.048	-0.075	0.0012	-0.0001	1.58
7	5.00	8.46	-0.02	0.221	-0.001	-0.001	0.0000	0.0000	
7	5.00	8.31	1.02	0.220	0.046	0.071	-0.0010	0.0005	1.54
7	5.00	8.31	3.08	0.224	0.154	0.210	-0.0014	-0.0061	1.37
7	5.00	8.17	5.15	0.22	.264	0.347	-0.0010	-0.0027	1.31
7	5.00	8.17	7.74	0.231	0.423	0.518	-0.0058	0.0032	1.23
7	5.00	8.17	10.31	0.235	0.600	0.686	-0.0108	0.0116	1.14
7	5.00	8.17	12.96	0.240	0.813	0.853	-0.0154	0.0142	1.05
7	5.00	8.17	15.56	0.245	1.035	1.020	-0.0154	0.0141	0.99
8	5.00	9.67	-5.26	0.240	-0.270	-0.467	0.0034	-0.0005	1.73
8	5.00	9.67	-3.17	0.244	-0.152	-0.288	0.0040	0.0019	1.90
8	5.00	9.67	-1.07	0.243	-0.047	-0.102	0.0015	-0.0031	2.17
8	5.00	9.67	0.01	0.241	0.000	0.001	0.0000	0.0000	
8	5.00	9.67	1.06	0.241	0.051	0.099	-0.0024	0.0031	1.93
8	5.00	9.67	3.14	0.242	0.162	0.283	-0.0039	-0.0009	1.75
8	5.00	9.50	5.25	0.247	0.302	0.478	-0.0017	0.0034	1.58
8	5.00	9.50	7.87	0.254	0.487	0.696	-0.0049	0.0092	1.43
8	5.00	9.50	10.45	0.261	0.704	0.924	-0.0105	0.0146	1.31
8	5.00	9.50	13.19	0.266	0.947	1.168	-0.0142	0.0164	1.23
8	5.00	9.33	15.77	0.269	1.199	1.398	-0.0164	0.0186	1.17

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	6.00	7.13	-5.08	0.222	-0.250	-0.252	0.0170	-0.0012	1.01
6	6.00	7.13	-1.97	0.225	-0.091	-0.098	-0.0019	0.0116	1.08
6	6.00	7.13	-0.95	0.222	-0.041	-0.045	-0.0001	0.0075	1.12
6	6.00	7.13	0.07	0.220	0.003	0.003	0.0000	-0.0006	
6	6.00	7.13	1.11	0.221	0.049	0.058	-0.0030	0.0058	1.20
6	6.00	7.13	2.16	0.226	0.097	0.106	-0.0191	0.0022	1.10
6	6.00	7.13	3.16	0.233	0.147	0.152	-0.0430	0.0045	1.04
6	6.00	7.13	4.17	0.239	0.199	0.201	-0.0278	-0.0112	1.01
6	6.00	7.13	5.21	0.245	0.255	0.251	-0.0274	-0.0112	0.98
6	6.00	7.13	7.78	0.250	0.403	0.370	-0.0294	-0.0073	0.92
6	6.00	7.13	10.37	0.255	0.568	0.490	-0.0250	-0.0133	0.86
6	6.00	7.13	12.95	0.260	0.755	0.613	-0.0280	-0.0105	0.81
6	6.00	7.13	15.59	0.243	0.965	0.730	-0.0359	-0.0054	0.76
7	6.00	7.58	-5.12	0.203	-0.272	-0.344	-0.0294	0.0220	1.27
7	6.00	7.58	-3.04	0.202	-0.152	-0.206	-0.0005	0.0095	1.35
7	6.00	7.58	-2.00	0.201	-0.100	-0.138	0.0031	0.0062	1.38
7	6.00	7.44	-0.96	0.200	-0.048	-0.068	-0.0004	0.0034	1.42
7	6.00	7.44	0.09	0.198	0.004	0.006	0.0000	-0.0003	
7	6.00	7.44	1.15	0.199	0.058	0.077	0.0052	-0.0024	1.33
7	6.00	7.44	2.21	0.201	0.112	0.145	0.0042	-0.0025	1.30
7	6.00	7.44	3.25	0.202	0.168	0.215	0.0028	-0.0040	1.28
7	6.00	7.44	4.29	0.203	0.229	0.284	-0.0034	-0.0065	1.24
7	6.00	7.44	5.37	0.203	0.296	0.353	-0.0026	-0.0020	1.19
7	6.00	7.44	7.96	0.205	0.474	0.520	-0.0054	-0.0032	1.10
8	6.00	8.00	-5.28	0.208	-0.314	-0.474	0.0162	-0.0216	1.51
8	6.00	8.00	-3.23	0.212	-0.177	-0.291	0.0084	-0.0222	1.65
8	6.00	7.83	-2.16	0.206	-0.114	-0.196	0.0146	-0.0265	1.73
8	6.00	7.83	-1.13	0.201	-0.060	-0.103	0.0165	-0.0257	1.72
8	6.00	7.83	-0.10	0.198	-0.005	-0.009	0.0002	-0.0001	
8	6.00	7.83	0.97	0.197	0.051	0.085	-0.0022	0.0008	1.68
8	6.00	7.83	2.07	0.197	0.111	0.178	0.0105	-0.0220	1.60
8	6.00	7.83	3.11	0.200	0.179	0.270	0.0183	-0.0414	1.51
8	6.00	7.83	4.14	0.203	0.246	0.355	0.0135	-0.0399	1.45
8	6.00	7.67	5.19	0.207	0.320	0.444	0.0078	-0.0365	1.39
8	6.00	7.67	7.85	0.218	0.529	0.660	-0.0021	-0.0311	1.25

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	2.53	11.50	-3.23	0.311	-0.174	-0.155	0.0025	0.0031	0.89
6	2.53	11.63	0.01	0.307	0.001	0.001	0.0000	0.0000	
6	2.53	11.38	1.08	0.306	0.056	0.054	-0.0027	-0.0007	0.97
6	2.53	11.63	3.26	0.310	0.175	0.157	-0.0061	-0.0038	0.90
6	2.53	11.63	5.51	0.320	0.325	0.267	-0.0081	-0.0092	0.82
6	2.53	11.75	8.19	0.323	0.516	0.395	-0.0090	-0.0121	0.77
6	2.53	11.75	10.91	0.320	0.749	0.533	-0.0101	-0.0103	0.71
7	2.53	13.42	-3.33	0.301	-0.183	-0.256	0.0044	0.0027	1.40
7	2.53	13.42	-0.05	0.303	-0.002	-0.004	0.0002	0.0000	
7	2.53	13.27	1.11	0.303	0.056	0.086	-0.0035	0.0000	1.54
7	2.53	13.56	3.31	0.309	0.184	0.264	-0.0086	-0.0040	1.43
7	2.53	13.56	5.54	0.319	0.333	0.448	-0.0133	-0.0046	1.34
7	2.53	13.71	8.34	0.328	0.559	0.656	-0.0193	-0.0032	1.17
7	2.53	13.71	9.95	0.326	-0.561	0.664	-0.0249	0.0020	-1.18
8	2.53	15.50	-3.44	0.310	-0.191	-0.368	0.0074	-0.0009	1.92
8	2.53	15.50	-0.03	0.306	-0.002	-0.003	0.0001	0.0000	
8	2.53	15.67	1.29	0.306	0.066	0.141	-0.0054	0.0004	2.15
8	2.53	15.67	3.43	0.315	0.196	0.386	-0.0134	-0.0049	1.97
8	2.53	15.50	5.76	0.325	0.357	0.660	-0.0221	-0.0047	1.85
8	2.53	15.83	8.83	0.332	0.633	0.982	-0.0336	0.0024	1.55

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	3.51	11.50	-5.21	0.309	-0.280	-0.258	0.0068	-0.0029	0.92
6	3.51	11.75	-3.22	0.303	-0.160	-0.164	0.0081	-0.0033	1.02
6	3.51	11.75	-1.05	0.292	-0.048	-0.061	0.0085	-0.0039	1.27
6	3.51	11.75	0.00	0.290	0.002	-0.007	0.0067	-0.0051	
6	3.51	11.75	1.11	0.291	0.058	0.051	0.0060	-0.0060	0.89
6	3.51	11.88	3.19	0.300	0.173	0.150	0.0052	-0.0088	0.86
6	3.51	11.88	5.31	0.308	0.303	0.252	0.0043	-0.0121	0.83
6	3.51	12.00	7.98	0.310	0.476	0.380	0.0028	-0.0117	0.80
6	3.51	12.00	10.61	0.307	0.674	0.510	-0.0003	-0.0100	0.76
6	3.51	12.00	13.36	0.309	0.897	0.643	-0.0037	-0.0090	0.72
6	3.51	12.00	16.03	0.306	1.128	0.769	-0.0028	-0.0121	0.68
7	3.51	13.56	-5.37	0.296	-0.312	-0.392	0.0027	0.0049	1.26
7	3.51	13.71	-3.23	0.292	-0.175	-0.239	0.0038	0.0039	1.37
7	3.51	13.71	0.05	0.279	0.003	0.004	-0.0001	-0.0001	
7	3.51	13.71	1.13	0.277	0.059	0.089	-0.0031	-0.0014	1.51
7	3.51	13.85	3.25	0.287	0.186	0.253	-0.0059	-0.0050	1.36
7	3.51	14.00	5.42	0.295	0.325	0.415	-0.0065	-0.0053	1.28
7	3.51	14.00	8.15	0.297	0.530	0.604	-0.0082	-0.0035	1.14
7	3.51	14.00	10.84	0.301	0.766	0.790	-0.0114	-0.0002	1.03
7	3.51	14.00	13.60	0.303	1.027	0.983	-0.0124	-0.0032	0.96
8	3.51	15.50	-5.50	0.302	-0.342	-0.565	0.0099	-0.0015	1.65
8	3.51	15.67	-3.31	0.301	-0.187	-0.342	0.0078	0.0020	1.83
8	3.51	15.50	-1.13	0.293	-0.057	-0.121	0.0033	-0.0007	2.12
8	3.51	15.67	0.04	0.285	0.002	0.004	-0.0001	0.0000	
8	3.51	15.83	3.36	0.293	0.201	0.358	-0.0090	-0.0072	1.78
8	3.51	15.83	5.58	0.305	0.363	0.589	-0.0137	-0.0084	1.62
8	3.51	16.00	8.39	0.310	0.605	0.854	-0.0198	-0.0035	1.41
8	3.51	16.00	11.19	0.315	0.899	1.116	-0.0256	-0.0004	1.24

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	5.00	10.88	-5.22	0.261	-0.244	-0.234	-0.0055	-0.0027	0.96
6	5.00	12.25	-3.11	0.266	-0.134	-0.144	-0.0015	-0.0008	1.07
6	5.00	12.50	-1.04	0.259	-0.042	-0.052	0.0001	-0.0028	1.24
6	5.00	12.50	0.04	0.254	0.002	0.002	0.0000	0.0001	
6	5.00	12.50	1.08	0.255	0.046	0.048	-0.0014	0.0015	1.04
6	5.00	13.75	3.17	0.263	0.139	0.139	-0.0030	-0.0031	1.00
6	5.00	13.75	5.25	0.272	0.236	0.228	-0.0038	-0.0022	0.97
6	5.00	13.75	7.86	0.276	0.371	0.341	-0.0068	0.0005	0.92
6	5.00	13.75	10.47	0.280	0.530	0.454	-0.0097	0.0034	0.86
6	5.00	13.75	13.05	0.288	0.699	0.561	-0.0117	0.0032	0.80
6	5.00	13.75	15.77	0.289	0.892	0.674	-0.0130	0.0014	0.76
7	5.00	14.58	-5.29	0.260	-0.251	-0.344	0.0059	0.0060	1.37
7	5.00	14.58	-3.17	0.256	-0.139	-0.206	0.0053	0.0048	1.48
7	5.00	14.58	-1.12	0.249	-0.047	-0.082	0.0021	0.0014	1.76
7	5.00	14.58	0.02	0.246	0.001	0.002	0.0000	0.0000	
7	5.00	16.04	1.02	0.248	0.044	0.071	0.0000	0.0026	1.60
7	5.00	16.04	3.15	0.256	0.145	0.210	-0.0008	-0.0003	1.45
7	5.00	16.04	5.28	0.263	0.258	0.348	0.0002	0.0014	1.35
7	5.00	16.04	8.04	0.267	0.424	0.518	-0.0047	0.0077	1.22
7	5.00	16.04	10.57	0.272	0.605	0.672	-0.0077	0.0138	1.11
7	5.00	16.04	13.24	0.278	0.812	0.837	-0.0065	0.0127	1.03
7	5.00	16.04	16.01	0.283	1.042	1.003	-0.0061	0.0122	0.96
8	5.00	18.33	-5.39	0.269	-0.266	-0.431	0.0017	-0.0013	1.62
8	5.00	18.33	-3.22	0.270	-0.151	-0.261	0.0049	-0.0006	1.73
8	5.00	18.33	-1.05	0.266	-0.049	-0.090	0.0022	-0.0037	1.83
8	5.00	18.33	0.06	0.260	0.003	0.005	-0.0001	0.0002	
8	5.00	18.33	1.06	0.260	0.044	0.097	-0.0021	0.0010	2.22
8	5.00	18.33	3.21	0.266	0.161	0.292	-0.0038	-0.0042	1.81
8	5.00	18.33	5.39	0.273	0.292	0.481	-0.0046	-0.0040	1.65
8	5.00	18.33	8.27	0.280	0.488	0.721	-0.0076	0.0015	1.48
8	5.00	18.33	10.83	0.283	0.694	0.932	-0.0081	0.0016	1.34

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP
6	6.00	11.75	-5.24	0.267	-0.255	-0.238	-0.0109	0.0158	0.94
6	6.00	11.75	-3.16	0.267	-0.146	-0.144	-0.0108	0.0157	0.99
6	6.00	11.75	-2.12	0.262	-0.095	-0.099	-0.0066	0.0095	1.04
6	6.00	11.75	-1.06	0.257	-0.046	-0.051	0.0020	-0.0008	1.11
6	6.00	11.88	0.02	0.255	0.001	0.001	0.0000	0.0000	
6	6.00	11.75	1.08	0.255	0.047	0.051	-0.0023	0.0003	1.09
6	6.00	11.63	2.11	0.245	0.095	0.093	-0.0086	0.0042	0.98
6	6.00	11.63	3.18	0.238	0.150	0.141	-0.0094	0.0038	0.94
6	6.00	11.63	4.19	0.239	0.203	0.185	-0.0113	0.0056	0.91
6	6.00	11.63	5.22	0.245	0.262	0.231	-0.0106	0.0061	0.88
6	6.00	11.75	7.85	0.252	0.414	0.349	-0.0181	0.0164	0.84
6	6.00	11.63	10.64	0.263	0.586	0.464	-0.0158	0.0121	0.83
7	6.00	12.40	-5.14	0.235	-0.276	-0.345	-0.0103	0.0200	1.25
7	6.00	12.40	-3.04	0.249	-0.151	-0.203	-0.0052	0.0120	1.34
7	6.00	12.25	-1.98	0.247	-0.095	-0.133	-0.0038	0.0075	1.39
7	6.00	12.25	0.13	0.243	0.006	0.009	0.0002	-0.0005	
7	6.00	12.25	1.22	0.244	0.058	0.064	-0.0010	-0.0025	1.45
7	6.00	12.40	2.30	0.248	0.113	0.153	-0.0010	-0.0073	1.36
7	6.00	12.10	3.32	0.246	0.171	0.218	-0.0130	0.0052	1.28
7	6.00	12.10	4.37	0.242	0.233	0.287	-0.0093	0.0038	1.23
7	6.00	12.54	5.47	0.245	0.298	0.354	-0.0075	-0.0003	1.19
7	6.00	12.25	6.12	0.250	0.479	0.527	-0.0073	-0.0024	1.10
8	6.00	14.50	-5.41	0.236	-0.321	-0.484	-0.0063	0.0188	1.51
8	6.00	14.33	-3.27	0.242	-0.179	-0.294	-0.0059	0.0157	1.64
8	6.00	14.33	-2.18	0.242	-0.111	-0.198	-0.0056	0.0111	1.78
8	6.00	14.17	-1.10	0.239	-0.056	-0.105	0.0001	0.0023	1.85
8	6.00	14.17	-0.01	0.237	-0.001	-0.001	0.0000	0.0000	
8	6.00	14.00	1.11	0.238	0.058	0.101	0.0010	-0.0027	1.72
8	6.00	14.00	2.18	0.240	0.110	0.192	0.0038	-0.0056	1.65
8	6.00	14.00	3.25	0.245	0.184	0.285	0.0004	-0.0069	1.55
8	6.00	14.00	4.38	0.249	0.260	0.378	0.0006	-0.0052	1.45
8	6.00	14.00	5.44	0.253	0.336	0.467	-0.0022	-0.0015	1.39
8	6.00	13.83	8.20	0.258	0.536	0.679	-0.0075	0.0074	1.27

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP	CA
6	2.53	6.25	-5.83	0.000	-0.330	-0.267	-0.0012	0.0061	0.81	0.154
6	2.53	6.25	-3.52	0.000	-0.193	-0.168	0.0013	0.0040	0.87	0.155
6	2.53	6.25	-1.12	0.000	-0.056	-0.052	0.0010	0.0019	0.92	0.147
6	2.53	6.25	0.14	0.000	0.007	0.007	-0.0001	-0.0002		0.140
6	2.53	6.25	1.18	0.000	0.062	0.057	-0.0019	-0.0035	0.92	0.149
6	2.53	6.25	2.32	0.000	0.121	0.108	-0.0037	-0.0048	0.89	0.148
6	2.53	6.25	3.48	0.000	0.189	0.162	-0.0049	-0.0061	0.86	0.153
6	2.53	6.25	4.61	0.000	0.258	0.215	-0.0066	-0.0080	0.83	0.158
6	2.53	6.25	5.79	0.000	0.327	0.261	-0.0073	-0.0092	0.80	0.157
7	2.53	7.15	-6.11	0.000	-0.374	-0.473	0.0109	0.0084	1.26	0.165
7	2.53	7.00	-3.56	0.000	-0.201	-0.272	0.0080	0.0099	1.36	0.157
7	2.53	7.00	-1.12	0.000	-0.058	-0.085	0.0033	0.0037	1.46	0.152
7	2.53	7.00	0.12	0.000	0.006	0.009	-0.0004	-0.0004		0.151
7	2.53	7.15	1.38	0.000	0.074	0.107	-0.0052	-0.0041	1.46	0.152
7	2.53	7.00	2.58	0.000	0.142	0.198	-0.0093	-0.0089	1.39	0.155
7	2.53	7.00	3.78	0.000	0.217	0.292	-0.0126	-0.0115	1.34	0.159
7	2.53	7.00	5.05	0.000	0.299	0.391	-0.0166	-0.0121	1.30	0.164
7	2.53	7.15	6.30	0.000	0.393	0.490	-0.0203	-0.0130	1.25	0.171
8	2.53	8.00	-6.53	0.000	-0.423	-0.705	0.0115	-0.0021	1.67	0.180
8	2.53	8.17	-3.71	0.000	-0.213	-0.393	0.0094	0.0049	1.85	0.168
8	2.53	8.00	-1.01	0.000	-0.052	-0.105	0.0040	0.0029	2.03	0.160
8	2.53	8.00	0.31	0.000	0.016	0.032	-0.0012	-0.0009		0.159
8	2.53	8.17	1.66	0.000	0.089	0.176	-0.0063	-0.0057	1.99	0.160
8	2.53	8.00	2.96	0.000	0.167	0.317	-0.0130	-0.0086	1.90	0.165
8	2.53	8.00	4.29	0.000	0.249	0.459	-0.0171	-0.0094	1.84	0.170
8	2.53	8.00	5.72	0.000	0.352	0.623	-0.0215	-0.0059	1.77	0.179

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP	CA
6	3.51	5.88	-5.61	0.000	-0.313	-0.260	-0.0045	0.0080	0.83	0.134
6	3.51	5.88	-3.32	0.000	-0.169	-0.155	0.0000	0.0060	0.91	0.132
6	3.51	5.88	-1.08	0.000	-0.052	-0.050	0.0013	0.0027	0.96	0.124
6	3.51	5.88	0.02	0.000	0.001	0.001	0.0000	0.0000		0.124
6	3.51	5.88	1.14	0.000	0.059	0.057	-0.0003	-0.0012	0.97	0.125
6	3.51	5.88	2.23	0.000	0.117	0.108	-0.0014	-0.0031	0.92	0.128
6	3.51	5.88	3.30	0.000	0.180	0.157	-0.0017	-0.0048	0.87	0.131
6	3.51	5.88	4.45	0.000	0.245	0.207	-0.0014	-0.0056	0.84	0.135
6	3.51	5.88	5.57	0.000	0.315	0.257	-0.0014	-0.0062	0.82	0.138
7	3.51	6.71	-5.37	0.000	-0.317	-0.367	-0.0054	0.0038	1.22	0.131
7	3.51	6.85	-3.06	0.000	-0.170	-0.226	0.0001	0.0028	1.32	0.125
7	3.51	6.85	-0.66	0.000	-0.037	-0.054	0.0010	0.0025	1.46	0.120
7	3.51	6.71	0.45	0.000	0.025	0.037	-0.0006	-0.0017		0.120
7	3.51	6.71	1.61	0.000	0.088	0.124	-0.0029	-0.0027	1.41	0.124
7	3.51	6.85	3.90	0.000	0.233	0.295	-0.0078	-0.0091	1.26	0.133
7	3.51	6.85	5.02	0.000	0.309	0.373	-0.0091	-0.0103	1.21	0.137
7	3.51	6.85	6.23	0.000	0.391	0.452	-0.0115	-0.0124	1.16	0.143
8	3.51	7.50	-5.79	0.000	-0.377	-0.592	-0.0007	0.0103	1.57	0.151
8	3.51	7.50	-3.25	0.000	-0.194	-0.338	0.0006	0.0026	1.74	0.137
8	3.51	7.50	-0.72	0.000	-0.042	-0.081	0.0008	-0.0003	1.93	0.132
8	3.51	7.50	0.43	0.000	0.025	0.048	-0.0005	0.0001		0.132
8	3.51	7.33	1.65	0.000	0.095	0.181	-0.0010	-0.0047	1.90	0.135
8	3.51	7.50	2.85	0.000	0.169	0.305	-0.0056	-0.0050	1.80	0.139
8	3.51	7.50	4.07	0.000	0.253	0.433	-0.0064	-0.0069	1.71	0.145
8	3.51	7.50	5.30	0.000	0.349	0.565	-0.0098	-0.0062	1.62	0.151
8	3.51	7.67	6.57	0.000	0.452	0.684	-0.0111	-0.0033	1.51	0.158

L/D	M	RE-06	ALPHA	PD/V	NFC	PMC	SFC	YMC	XCP	CA
6	5.00	6.75	-5.45	0.000	-0.261	-0.242	-0.0045	0.0086	0.93	0.101
6	5.00	7.13	-3.26	0.000	-0.150	-0.147	-0.0017	0.0082	0.98	0.093
6	5.00	7.13	-1.06	0.000	-0.047	-0.050	0.0000	0.0040	2.17	0.089
6	5.00	7.13	0.04	0.000	0.002	0.002	0.0000	-0.0002		0.089
6	5.00	7.13	1.14	0.000	0.051	0.055	0.0009	-0.0022	1.08	0.089
6	5.00	7.13	2.23	0.000	0.098	0.100	0.0017	-0.0051	1.02	0.092
6	5.00	7.13	3.30	0.000	0.149	0.147	0.0014	-0.0064	0.98	0.095
6	5.00	7.13	4.35	0.000	0.204	0.193	0.0000	-0.0094	1.43	0.10[illegible]
6	5.00	7.00	5.45	0.000	0.259	0.240	-0.0001	-0.0078	0.93	0.103
7	5.00	8.02	-5.59	0.000	-0.299	-0.376	-0.0022	0.0118	1.25	0.108
7	5.00	8.31	-3.35	0.000	-0.170	-0.229	-0.0002	0.0113	1.35	0.100
7	5.00	8.31	-1.08	0.000	-0.053	-0.080	0.0014	0.0032	1.50	0.094
7	5.00	8.31	0.02	0.000	0.001	0.002	0.0000	-0.0001		0.093
7	5.00	8.46	1.17	0.000	0.054	0.078	0.0015	-0.0020	1.43	0.094
7	5.00	8.31	2.28	0.000	0.107	0.147	0.0012	-0.0044	1.37	0.099
7	5.00	8.31	3.41	0.000	0.168	0.225	0.0012	-0.0067	1.34	0.101
7	5.00	8.31	4.49	0.000	0.228	0.295	0.0004	-0.0071	1.29	0.106
7	5.00	8.31	5.60	0.000	0.296	0.368	0.0010	-0.0022	1.24	0.112
8	5.00	8.83	-5.54	0.000	-0.322	-0.489	-0.0112	0.0129	1.52	0.114
8	5.00	9.17	-3.07	0.000	-0.165	-0.277	-0.0025	0.0136	1.68	0.106
8	5.00	9.50	-0.77	0.000	-0.038	-0.071	0.0001	0.0032	1.87	0.100
8	5.00	9.50	0.40	0.000	0.020	0.037	-0.0001	-0.0017		0.099
8	5.00	9.50	1.59	0.000	0.077	0.151	-0.0003	-0.0013	1.96	0.100
8	5.00	9.50	2.73	0.000	0.142	0.260	-0.0015	-0.0055	1.83	0.128
8	5.00	9.50	3.88	0.000	0.209	0.360	-0.0021	-0.0071	1.72	0.108
8	5.00	9.50	5.07	0.000	0.285	0.463	-0.0017	-0.0039	1.63	0.115
8	5.00	9.50	6.04	0.000	0.352	0.546	-0.0019	-0.0003	1.55	0.120

APPENDIX A - TABULATED DATA

LIST OF SYMBOLS

CA	axial force coefficient, C_{A_c}
L/D	model length to diameter ratio
M	test section Mach number
NFC	normal force coefficient
PD/V	dimensionless spin rate
PMC	pitching moment coefficient
RE-06	Reynolds number based on model length, millions
SFC	side force coefficient
XCP	center of pressure, calibers from c.g.
YMC	yawing moment coefficient
α	angle of attack, deg

LIST OF SYMBOLS

C_{A_c}	axial force coefficient, $C_{A_c} = C_{A_t} - C_{A_b}$
C_{A_b}	base axial force coefficient
C_{A_t}	total axial force coefficient
C_m	pitching moment coefficient
C_{m_α}	slope of the pitching moment coefficient
C_n	yawing moment coefficient
$C_{n_{p\alpha}}$	$d/d\alpha\ (C_n)/(pd/V)$
C_N	normal force coefficient
C_{N_α}	slope of the normal force coefficient
C_Y	side force coefficient
$C_{Y_{p\alpha}}$	$d/d\alpha\ (C_Y)/(pd/V)$
c.g.	center of gravity, 0.6L from projectile nose
d,D	projectile diameter
L	projectile length
M	Mach number
p	model spin rate, radians/sec
P_o	tunnel supply pressure, kPa
Re_ℓ	Reynolds number based on model length
T_o	Tunnel stagnation temperature, K
X_{cp}	center of pressure, calibers from c.g.

DISTRIBUTION LIST

No. of Copies	Organization
12	Administrator Defense Technical Info Center ATTN: DTIC-DDA Cameron Station Alexandria, VA 22314
1	Commander US Army Materiel Development and Readiness Command ATTN: DRCDMD-ST 5001 Eisenhower Avenue Alexandria, VA 22333
9	Commander US Army Armament Research and Development Command ATTN: DRDAR-TDC DRDAR-TSS DRDAR-LCA-F Mr. D. Mertz Mr. E. Falkowski Mr. A. Loeb Mr. R. Kline Mr. S. Kahn Mr. H. Hudgins Dover, NJ 07801
1	Commander US Army Armament Materiel Readiness Command ATTN: DRSAR-LEP-L Rock Island, IL 61299
1	Director US Army Armament Research and Development Command Benet Weapons Laboratory ATTN: DRDAR-LCB-TL Watervliet, NY 12189
1	Commander US Army Aviation Research and Development Command ATTN: DRDAV-E 4300 Goodfellow Blvd. St. Louis, MO 63120

No. of Copies	Organization
1	Director US Army Air Mobility Research and Development Laboratory Ames Research Center Moffett Field, CA 94035
1	Commander US Army Communications Rsch and Development Command ATTN: DRSEL-ATDD Fort Monmouth, NJ 07703
1	Commander US Army Electronics Research and Development Command Technical Support Activity ATTN: DELSD-L Fort Monmouth, NJ 07703
2	Commander US Army Missile Command ATTN: DRSMI-R DRSMI-RDK Mr. R. Deep Redstone Arsenal, AL 35898
1	Commander US Army Missile Command ATTN: DRSMI-YDL Redstone Arsenal, AL 35898
1	Commander US Army Tank Automotive Command ATTN: DRSTA-TSL Warren, MI 48090
1	Director US Army TRADOC Systems Analysis Activity ATTN: ATAA-SL White Sands Missile Range NM 88002
1	Commander US Army Research Office P. O. Box 12211 Research Triangle Park NC 27709

DISTRIBUTION LIST

No. of Copies	Organization	No. of Copies	Organization
1	Commander US Naval Air Systems Command ATTN: AIR-604 Washington, D. C. 20360	1	ACUREX Corporation/Aerotherm ATTN: Dr. M. J. Abbett 485 Clyde Avenue Mountain View, CA 94042
2	Commander David W. Taylor Naval Ship Research and Development Center ATTN: Dr. S. de los Santos Mr. Stanley Gottlieb Bethesda, Maryland 20084	1	AFWL/SUL Kirtland AFB, NM 87117
4	Commander US Naval Surface Weapons Center ATTN: Dr. T. Clare, Code DK20 Mr. P. Daniels Mr. D. A. Jones III Mr. L. Mason Dahlgren, VA 22448	1	AVCO Corporation Research-Advanced Development Division 201 Lowell Street Wilmington, MA 01887
4	Commander US Naval Surface Weapons Center ATTN: Code 312 Dr. W. Yanta Code R44 Dr. C. Hsieh Dr. T. Zien Dr. R. U. Jettmar Silver Spring, MD 20910	1	Bendix Guided Systems Division ATTN: MS 2/17A (S. Wasserman) Teterboro, NJ 97608
1	Commander US Naval Weapons Center ATTN: Code 3431, Tech Lib China Lake, CA 93555	1	Nielsen Engineering & Research, Inc. ATTN: Dr. S. Stahara 510 Clyde Avenue Mountain View, CA 94043
1	Director NASA Langley Research Center ATTN: NS-185, Tech Lib Langley Station Hampton, VA 23365	2	Sandia Laboratories ATTN: Technical Staff, Dr. W.L. Oberkampf Aeroballistics Division 5631, H.R. Vaughn Albuquerque, NM 87115
2	Commandant US Army Infantry School ATTN: ATSH-CD-CSO-OR Fort Benning, GA 31905	1	Massachusetts Institute of Technology ATTN: Tech Library 77 Massachusetts Avenue Cambridge, MA 02139
		1	University of Delaware Mechanical and Aerospace Engineering Department ATTN: Dr. J. E. Danberg Newark, DE 19711

Aberdeen Proving Ground

Dir, USAMSAA
ATTN: DRXSY-D
DRXSY-MP, H. Cohen

DISTRIBUTION LIST

Cdr, USATECOM
  ATTN: DRSTE-TO-F

Dir, USACSL, Bldg. E3516, EA
    ATTN: DRDAR-CLB-PA
          DRDAR-CLN
          DRDAR-CLJ-L

USER EVALUATION OF REPORT

Please take a few minutes to answer the questions below; tear out this sheet, fold as indicated, staple or tape closed, and place in the mail. Your comments will provide us with information for improving future reports.

1. BRL Report Number____________________________________

2. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which report will be used.)

____

____

____

3. How, specifically, is the report being used? (Information source, design data or procedure, management procedure, source of ideas, etc.)____

____

____

4. Has the information in this report led to any quantitative savings as far as man-hours/contract dollars saved, operating costs avoided, efficiencies achieved, etc.? If so, please elaborate.

____

____

5. General Comments (Indicate what you think should be changed to make this report and future reports of this type more responsive to your needs, more usable, improve readability, etc.)____________

____

____

____

6. If you would like to be contacted by the personnel who prepared this report to raise specific questions or discuss the topic, please fill in the following information.

Name:______________________________________

Telephone Number:______________________________________

Organization Address:______________________________________

____

____